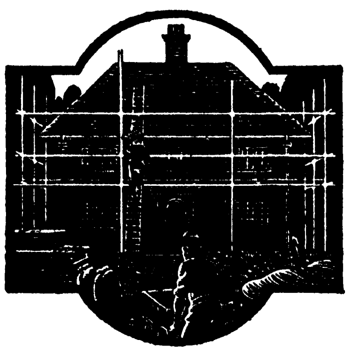
PRACTICAL
BUILDING
REPAIRS
ILLUSTRATED

AN AUTHORITATIVE AND PRACTICAL GUIDE TO THE BEST METHODS AND MATERIALS EMPLOYED IN THE REPAIR, DECORATION AND MAINTENANCE OF BUILDINGS

Edited by

R. GREENHALGH, A.I.STRUCT.E.



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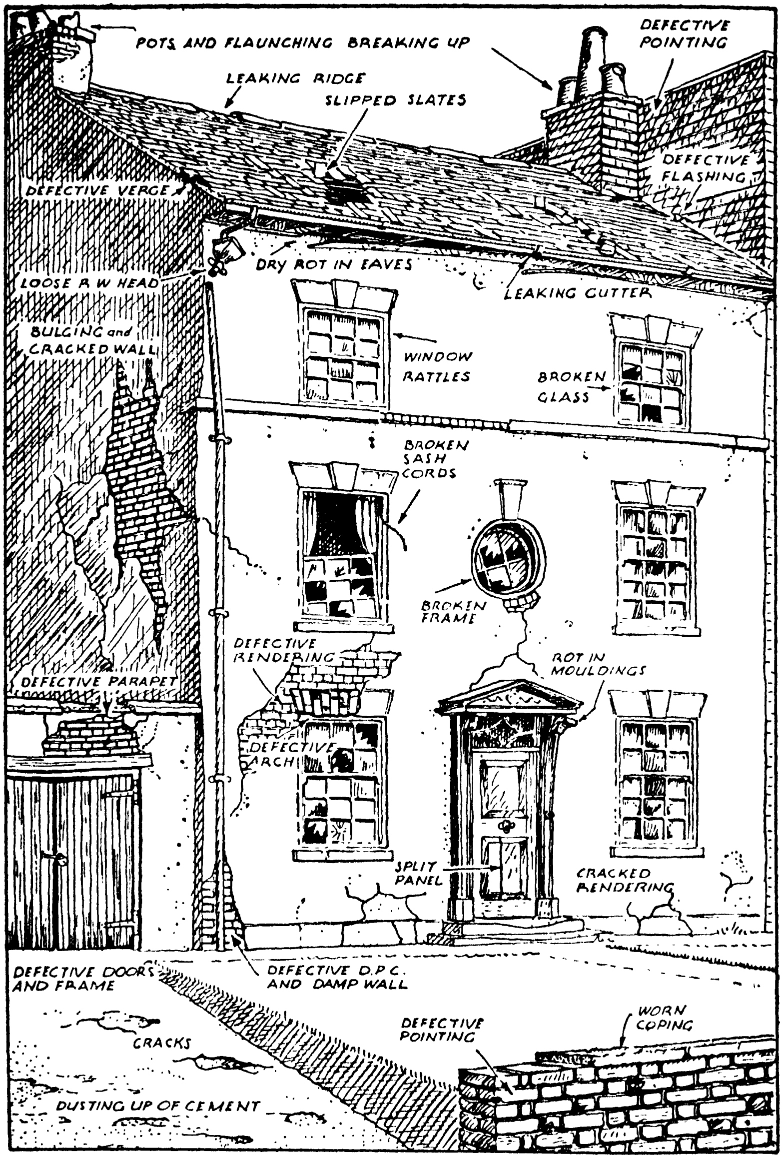

EXTERNAL DEFECTS IN DAMAGED BUILDINGS

A composite drawing indicating some of the many defects that may have to be remedied on the outsides of buildings ; at some time during the life of a building the walls, doors, windows, roof and chimneys may all have to be repaired.

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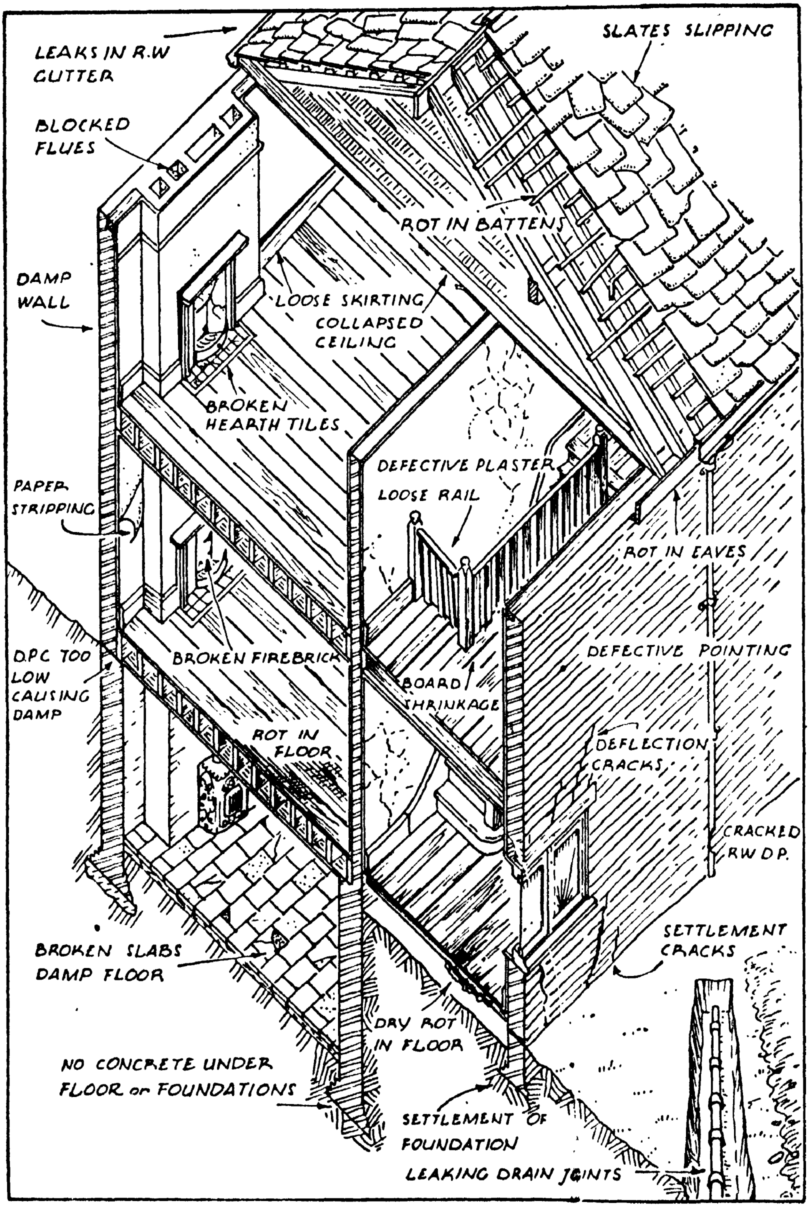


HOUSE REPAIRS FOR THE JOBBING BUILDER

An axonometric sketch showing the internal structure of a house, and indicating a few of the many repairs the jobbing builder may be called upon to undertake during the normal course of his duties. In addition to these there are many other repair jobs, which are fully described and illustrated throughout the book.

CHAPTER 1

WALL BUILDING AND REPAIRS

TYPES OF WALLS AND BONDS. STANDARD BRICK SIZES. REPAIR OF FACINGS. MORTARS. JOINTING AND POINTING. RE-POINTING OLD WALLS. TREATMENT OF EFFLORESCENCE. SURFACE REPAIRS. STONE WALLS. PRESERVATION. ASHLAR. MORTAR FOR STONEWORK. JOINTS. DAMPPROOF COURSES. COMMON DEFECTS. WATERPROOFING MATERIALS. CAUSE AND TREATMENT OF DAMPNESS. RENDERINGS. LEAKAGES. TILE AND SLATE HANGING. CONDENSATION. DANGEROUS WALLS. PLASTERING.

THE important part played by walls in all forms of building construction makes their effective repair and maintenance a matter of great importance, as the stability of the whole structure may well depend on the condition of the walls.

Work connected with building repairs naturally begins with the subject of walls, and it is essential that the various wall types, their functions, the materials of which they are composed, and the defects to which they are subject and the methods employed in their repair are fully understood.

It is important to distinguish between a load-bearing wall, and a wall which encloses floor space but does not support any load other than its own dead weight.

A *load-bearing wall* supports other parts of the building—floors, ceilings, upper walls, and roofs. This is the type of wall commonly found in houses, and in older buildings of the traditional kind.

A *panel or screen wall* is a filling of solid material in a structural frame of steel or reinforced concrete. This type of wall is found in a large number of our modern buildings.

A brick wall consists of separate brick units cemented and bonded together. All normal building bricks should be hard, uniformly burnt and free from cracks. When struck together they should give a clear metallic sound. Defective bricks give a dull sound. In any delivery a few defective bricks must be expected.

Types of Bonds

There are a number of recognised bonds to which certain rules of construction apply. In repair work the existing bond should be followed wherever possible.

Stretcher Bond. A brick laid with the long side showing on the wall face is called a *stretcher*. Stretcher bond consists of stretchers laid to overlap by a half-brick length, as in Fig. 1 A. This bond is used in walls half a brick ($4\frac{1}{2}$ in.) thick. It should not be used in thicker walls, as it does not provide a transverse bond.

Header Bond. A brick laid with an end showing on the face is called a *header*. If (Fig. 1 B) all the

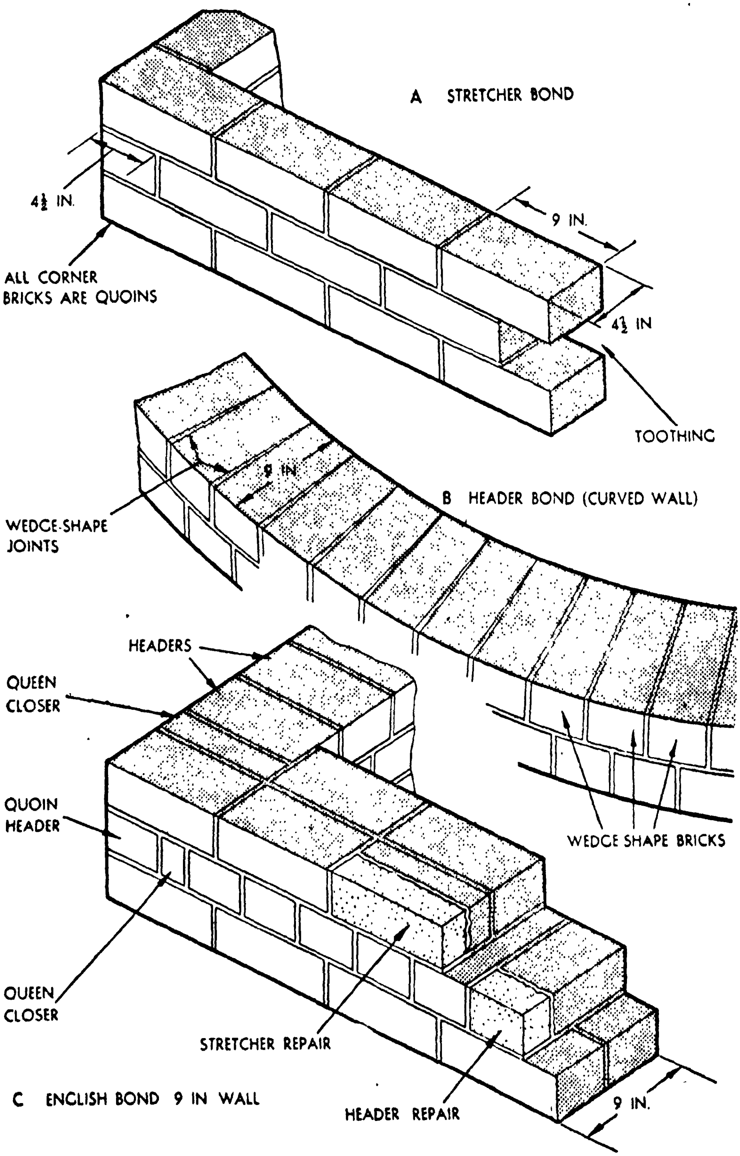


Fig. 1. Common bonds employed in wall construction. *A.* Stretcher bond; *B.* Header bond; *C.* English bond. Stretcher bond is used in 4½-in. walls, but is not used in walls of greater thickness as it does not provide a transverse bond. Header bond is used for curved walls and foundation footings. In English bond there are alternate courses of headers and stretchers.

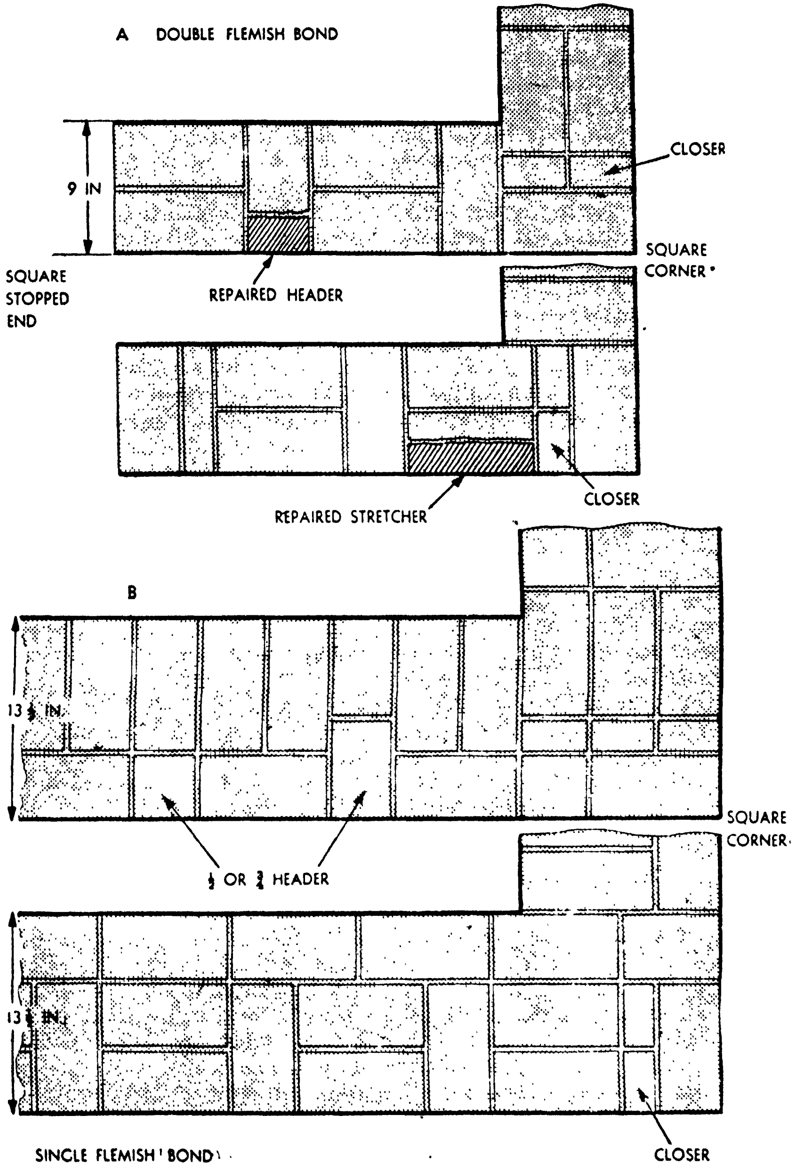


Fig. 2. *A.* Square stopped end 9 in. wall in Flemish bond, showing use of closer. Closers are 2¼ in. wide, and are employed to bring the ends or corners to a flush face. *B.* Single Flemish bond in a 13½-in. wall. This is a composite bond, with Flemish bond facing and English bond backing. The facing headers in alternate courses consist either of half-bats or three-quarter bats.

bricks are laid as headers, the bricks in courses overlapping by 2¼ in. (half the width of the header face), the bricks are said to be laid in *header bond*. This gives a strong transverse bond, but longitudinally it is inferior to stretcher bond, and the header arrangement does not look so pleasing as the stretcher arrangement. In practice, header bond is almost confined to two uses: for walls curved on plan, in which headers enable the curve to be followed closely; and in foundation footings.

English Bond. A row of bricks is called a *course.* If the bricks are laid in alternate courses of headers and stretchers, as shown in Fig. 1 C, the wall is in *English bond.* The vertical joints showing on the face of a wall are called *perpends.* In English bond the perpends are staggered by 2¼ in., so that there is a header above and below the middle of each stretcher.

Corners and ends. The bricks on the corner of a wall are called *quoin* bricks. A corner in English bond is illustrated in Fig. 1 C. Notice that a quoin header becomes a stretcher on turning the corner, and vice versa.

Use of Closers

A *stopped end* to a wall is shown in Fig. 2 A. At a corner and at a stopped end a brick smaller than the standard size, called a *closer*, must be used. A closer is 2¼ in. wide (half the width of a header). The purpose of the closer is to bring the end or corner to a flush face. There are three kinds of closer: *queen closer*, *bevelled closer*, and *king closer*. On the wall face they look the same. Usually the bricklayer cuts the closers from standard bricks.

An important rule of bonding is that *the closer is placed next to the quoin header*. Bonding in any particular bond varies with the thickness of the wall. In a 13½-in. wall in English bond a header course is backed with stretchers and vice versa. In an 18-in. wall, where both the inside and outside faces show stretchers, the middle of the course is filled with headers.

Double Flemish Bond. In each course of *double Flemish bond* there is a stretcher, then a header, another stretcher, and so on, as shown in Fig. 2 A. Each header is on the centre line of the stretchers above and below. In a 13½-in. wall it is necessary to use *half-bats* in the interior. A *bat* is a portion of a brick, other than a closer. As far as possible bats should be avoided, as they weaken the bond. In Flemish, as in English bond, a queen closer is placed next to the quoin header to form a stopped end or square corner.

Composite Bond

Single Flemish Bond may be used in walls 13½ in. thick or greater. It is a composite bond, with Flemish bond facing and English bond backing, as shown in Fig. 2 B. The facing headers in alternate courses consist either of half-bats or three-quarter bats.

English bond is stronger than Flemish bond. In Fig. 2 it will be seen that interior vertical joints in Flemish bond coincide in places, forming what are called *straight joints*, which in this case are 2¼ in. wide. Straight joints should be avoided as far as possible. In English bond there are no straight joints, beyond the joint thickness where joints cross. English bond is used in retaining walls and heavily loaded piers. Flemish bond is, however, quite strong enough

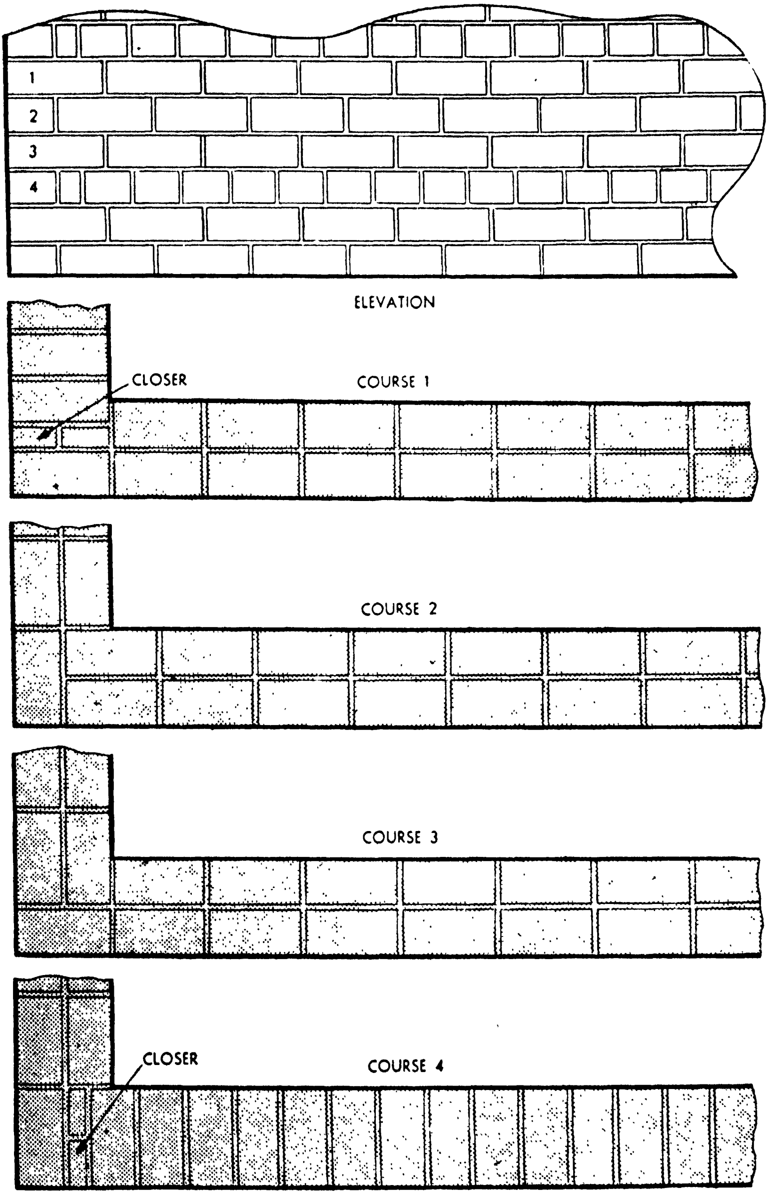


Fig. 3. Three-and-one bond in a 9-in. wall. In this bond there are three courses of stretchers to one course of headers. The stretcher courses are staggered $4\frac{1}{2}$ in. in relation to each other, but the stretchers are staggered $2\frac{1}{4}$ in. in relation to the header course. This bond is also known as English garden-wall bond.

for ordinary purposes, and it is usually considered a better-looking bond.

Where special facing bricks are used, English bond takes more facings than Flemish bond, so that English bond is more costly for such walls.

Three-and-one Bond consists of three courses of stretchers to one course of headers, as shown in Fig. 3. It is also called *English garden-wall bond*, because it was originally used for garden walls as a weaker kind of English bond. It is now used for a great variety of work, and is considered quite strong enough for ordinary wall loads. Notice that the bonding has the stretcher courses staggered 4½ in. in relation to one another, but the stretchers are staggered 2¼ in. in relation to the header course.

Three-and-one bond, as described above, is often used with walls having a facing brick thinner than the backing brick. The rise of the courses should be arranged so that each header course of facings can bond into the backing.

Flemish Garden-wall Bond. Another bond economical in facing bricks is the *Flemish garden-wall bond*. There are three stretchers to one header in each course. As the stretchers in each course are in groups of three, each header above is placed centrally over the middle stretcher of the group below. Like three-and-one bond, it is strong enough for all ordinary walls, but rather better in appearance.

Ornamental Patterns

Patterns are often introduced into facing work by using dark headers and light stretchers, or vice versa. In repairing such walls the pattern should be preserved by selecting headers and stretchers to agree in colour with the existing work. Otherwise the repaired portion will make an ugly patch. With some ornamental patterns herringbone and other fancy bonds are used. In repairing these it is essential to keep to the original design. Such work takes longer than plain work, and this should be allowed for in costing.

Sizes of Bricks

There are three standard sizes of bricks. All three are of one standard length, 8¾ in., and one standard width, 4$\frac{3}{16}$ in. There are also three standard thicknesses: 2 in., 2⅝ in., and 2⅞ in. Special facing bricks are made of any thickness between 1¼ in. and 2½ in.

In repairing old walls it may be found that the bricks do not comply with modern standard sizes. Old bricks of the Victorian period may be 3 in. or more in thickness, and bricks which are two or three hundred years old are usually 2¼ in. or less.

The question of brick size is very important in repair work. In repairing facings a brick size very near to the existing brick size must be selected. A near match for colour must also be obtained. In work in which appearance is important it may be necessary to have bricks specially made, though old bricks of the right size and colour may be obtainable from demolished portions of the building. This is a point to remember in estimating. If the brick surface is defective it is sufficient to cut it out to half its depth in the wall and replace with a new bat.

Bricks are not absolutely regular in size. Standard bricks may be plus or minus ⅛ in. in length and $\frac{1}{16}$ in. in width and depth.

This variation is adjusted in the joint thicknesses.

The bottom surface of a brick is called the *bed*. The horizontal mortar joints are called *bed joints*. The vertical joints on the face are called *perpends*. A good bricklayer takes care to keep the perpends on a true vertical line.

Mortars

The ingredients of mortars are described in Chapter 18. Mixes vary, but there are three distinct types:—

Portland Cement-Mortar. One part Portland cement to three parts clean sand makes a strong mortar. Place the cement on the sand and thoroughly mix dry, then add water through a rose sufficient to make a workable mix. Mix thoroughly before using. Use within twenty-five minutes—within half an hour of wet mixing the initial set takes place, and it would spoil the mortar to disturb it.

Lime-Mortar. One part grey lime to three parts clean sand makes a mortar of moderate strength. The slaking of lime is described in Chapter 18. There are a number of limes, each with individual characteristics. They should be used according to the makers' instructions.

Cement-Lime-Mortar. One part Portland cement, one part lime, and four parts clean sand is a good specification. This mortar is recommended in preference to cement or lime-mortar, as it combines adequate strength and durability with less shrinkage and expansion than a strong cement-mortar, so that small cracks in the joints are usually avoided. A cement-lime-mortar works easily off the trowel and enables the bricklayer to make a sound job with the minimum of trouble. The mortar should be used within three hours of mixing. Mix the sand-lime coarse stuff first and add the cement immediately before use. Using dry hydrated lime the complete mix may be prepared in one operation.

If the face joints are finished as the work proceeds, *i.e.*, drawing the trowel or other tool along the face of the joints to give a smooth durable finish, the work is said to be *jointed*. The mortar of the joint face is the same as that in the beds and other joints.

If the joints are raked out to a depth of at least ½ in. and then filled with a specially prepared mortar and smoothed with the trowel or other tool, the work is said to be *pointed*. Special coloured aggregates and pigments are sold for making coloured pointing mortar.

Jointing and pointing finishes of various types are illustrated in Fig. 4. Weathered pointing is supposed to be the most durable, as the rain runs off the edge. Struck pointing should never be used in outside work, as the water rests on the edge. Flush pointing is often used in modern work, and looks well with coloured mortar. The hollow keyed joint also looks well, as the recess throws a shadow. In some work the bed joints are recessed and the perpends are flush.

Tuck Pointing

For renovating old brickwork where the bricks have crumbled at the edges, *tuck pointing* is sometimes used. It consists of a stopping of lime or cement-lime and sand mortar coloured to the tint of the bricks. White cement jointing mortar is then pressed into the stopping with a jointer tool, the

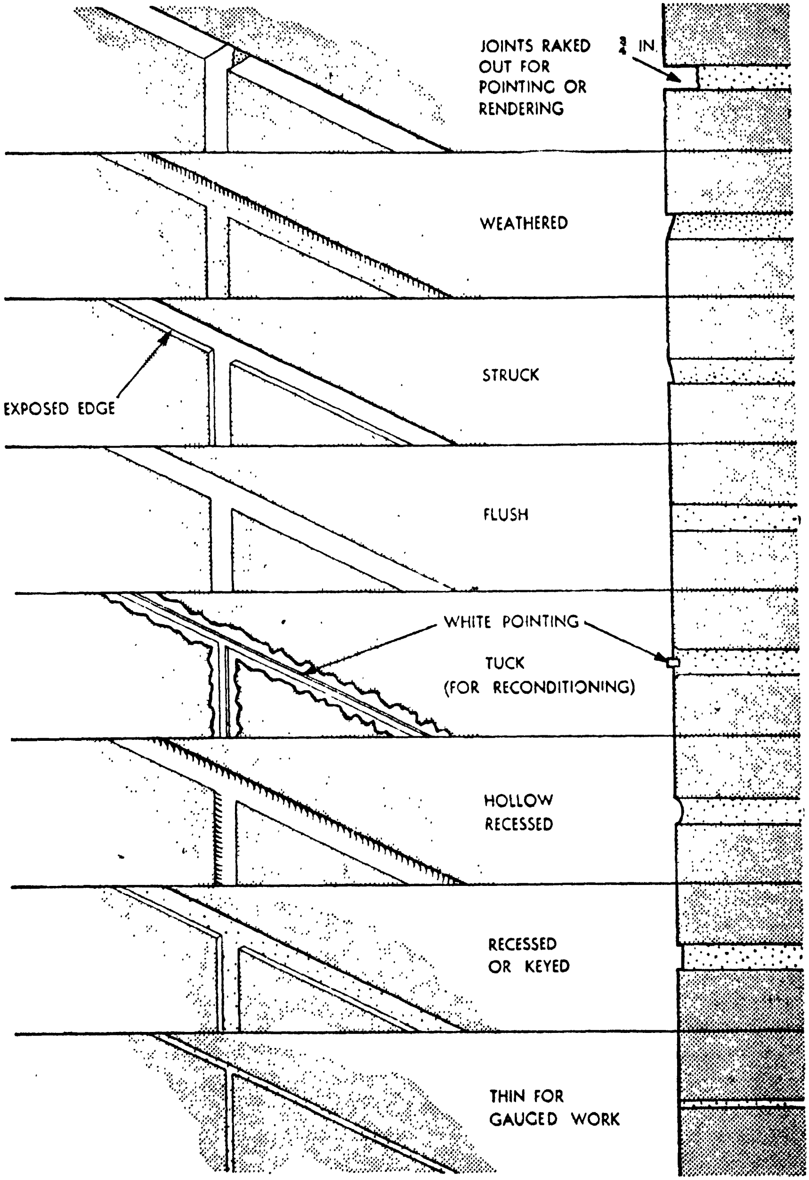


Fig. 4. Jointing and pointing finishes. Weathered pointing is considered to be the most durable, but flush pointing is frequently used in modern work. Tuck pointing is often used for renovating old brickwork. It consists of a flushing of lime and sand mortar coloured to the tint of the bricks, into which is pressed a narrow fillet of white mortar. This method is used when the bricks are badly damaged.

top and bottom edges being cut off with a frenchman worked along a bevelled straightedge or rule.

The coloured wash for the stopping may be mixed with green copperas and yellow ochre for a yellow tint, or red ochre, alum and a little lime for a red tint. The white joint worked on to the stopping should be $\frac{1}{4}$ in. deep from top to bottom, and should project about $\frac{1}{16}$ in.

This method should be adopted only if the edges of the bricks are so badly damaged as to make ordinary pointing inadvisable.

The projecting portion is sometimes formed with the stopping material. This is called *bastard tuck pointing.*

Re-pointing Old Walls is often a major item in building repairs. Although it appears to be a simple job, certain precautions must be taken or the pointing material will drop out in a short time. Much re-pointing is, in fact, made necessary by the faulty methods used in the original work.

The old joints must first be well raked out to a depth of between $\frac{1}{2}$ in. and $\frac{3}{4}$ in. If the edges of the bricks have crumbled badly the raking should be done to the full $\frac{3}{4}$ in. If the mortar in the joints is very weak, 1 in. depth will not be too much. The condition of the work should be taken into consideration.

Weak Adhesion

The next operation is to clean the raked joints by brushing away all loose material and dust. Shortly before re-pointing commences the raked and brushed joints should be well wetted. If the work is being done in hot dry weather thorough wetting will be necessary. If the work is nearly dry it will rapidly absorb the moisture from the pointing mortar, which will result in excessive shrinkage and weak adhesion. The pointing material may then drop out within a short time. So the importance of wetting the work, and pointing before it dries, is evident. This applies to both old and new walls.

Causes of Decay

The mix for the pointing mortar requires careful consideration. The Building Research Station, at Garston near Watford, have found that if the pointing mortar is much stronger than the bricks it is likely to cause or accelerate the decay of the bricks. Cases have occurred where re-pointing with a strong cement-mortar has been followed by the breaking-up of the edges of the bricks, and even the whole brick surface, leaving the pointing projecting. This is due to the crystallisation of salts contained in the mortar or brick. If the mortar is very dense these salts crystallise in the surface skin of the brick and cause disintegration.

Mortar should be approximately equal in strength and density to the brick. For bricks of medium-strength a lime-cement-mortar probably gives the best result. A mixture of one part Portland cement, two parts non-hydraulic lime hydrate or putty and nine parts clean sand is recommended. This will be quite strong enough. For bricks of low strength a 1 : 3 : 12 mix is recommended. If cement-mortar is used it should be a lean mix; for bricks of medium strength not richer than 1 : $3\frac{1}{2}$.

A cement-lime mix is best for re-pointing, as it works easily off the trowel. Press it well into the joint, but do not iron the surface

too much. If a rough surface is desired use a piece of wood of suitable shape, or a piece of wood with a bit of canvas tacked to it.

Efflorescence is the name given to the white deposit often seen on the face of a wall. This deposit consists of chemical salts such as sulphates of calcium, sodium, potassium and magnesium. These salts are soluble in water, and when water dries out from the wall the salts are drawn to the surface and to the surface skin where they crystallise. When crystallisation takes place it is accompanied by expansion which may disrupt the brickwork and/or mortar. This is a frequent cause of surface decay in walls. The salts may be contained in the bricks as they are sometimes present in the clay from which the bricks are manufactured, or they may be in the mortar as they are frequently present in Portland cement.

Non-hydraulic and moderately hydraulic limes rarely contain more than a very slight amount of salts. They are, therefore, recommended for re-pointing. With regard to the particular makes of bricks, experience is the best guide. Salts can be drawn into the wall from an outside source; sometimes from filling material such as ashes, and even from soil. Ground ashes used in mortar may also introduce salts into the wall.

Treatment of Efflorescence

Unfortunately there is no rapid or certain cure for efflorescence. From the foregoing description of its cause it will be readily understood that, as water alternatively soaks into and is evaporated from the wall, it draws more and more of the salts from the wall material. When there is a good deposit of the salts on the wall face it may be brushed or washed off. There is no effective chemical treatment. If the deposit is removed further deposits will occur as the rain soaks into and dries out of the wall. But washing and brushing get rid of some of the salts. The trouble is persistent but necessarily reduces with the passage of time.

Surface Repairs

In addition to re-pointing an old wall may require general surface repair. The bricks may be badly decayed in places. Frost may be responsible for this. As water freezes into cracks and crevices it expands, and the pressure thus set up tends to disintegrate the wall surface. Some bricks may be thus decayed to half their thickness.

Two distinct treatments are available. Defective bricks may be cut out and replaced by new bricks. The new bricks must match the old as closely as possible. They should not be very much harder than those existing, or efflorescent salts may be diverted into the remaining old brickwork and disrupt it. A cement-lime-mortar is recommended for such repairs, unless the original work is in cement-mortar, and strength is of prime importance. The existing work must be well wetted before setting the new bricks.

If the wall is a large one and the decay extensive, repairing it by this method may amount to an entirely new facing. In some cases it is advisable to build a new "skin" of 4½-in. brickwork on to the wall, but careful consideration must be given to the detailing of openings for windows and doors. Needless to say, the new skin should be bonded into the old work.

An alternative method is to cut away all loose and defective material from the wall face, fill up holes with a cement-lime-mortar, and then render the whole surface. To do this successfully the brickwork surface left after removing loose material must be firm and in reasonably good condition. Otherwise it may cause the failure of the rendering.

Stone Walls

Old load-bearing stone walls are usually of stone throughout, though the interior material may be inferior to the facing material.

Modern load-bearing stone walls are usually backed with brick. This has the advantages of reducing the permissible thickness, of giving a regular surface for interior plastering, and of reducing the labour and material required.

Stone is used as a facing to modern framed buildings. It has already been explained that in a framed building the walls are merely panels and bear no load. Stone facing used in such buildings is merely a facing or veneer on the panel walls. It may be bonded into a brick or concrete backing, or the stone may be in the form of thin facing slabs secured to the backing with metal holdfasts.

In repair work it is important to discover the type of construction and the nature of the wall in cross section. As in brick walls, care must be taken in removing material from a load-bearing wall.

Rubble may consist of rough pieces of stone used as they come from the quarry, or the stones may be more or less tooled to bring them to rectangular shapes. The principal varieties of rubble walls (Fig. 5) are:

Uncoursed Random Rubble. The stones are used as quarried, though a little tooling is necessary to make some of them fit in. They are not laid to courses, but the beds should be horizontal. Transverse bond is achieved by fixing one large stone, the thickness of the wall, to about each square yard. Joints are necessarily thick in places, and care should be taken to fill up all joints with mortar. The interior is usually grouted. A grout is a thin mortar poured into the interior joints. Boundary walls are sometimes laid dry, though the coping course is set in mortar.

Random Rubble in Courses. The stones are roughly squared with the hammer, and the work is laid to rough courses about 18 in. thick. There is more labour in this work, but it is stronger and neater than uncoursed work.

Squared Rubble in Courses. Hammer and chisel are used to square up the largest stones for the facing work. The work is laid in courses about 18 in. thick, and jambs and corners are formed with squared stones. This makes quite a sound job of neat appearance without involving expensive tooling.

Square Snecked Rubble. Stone of a type which is found in horizontal strata breaks into regular thicknesses and can be easily tooled in square shapes of random sizes. All beds are level, but the stones are not laid to courses. Continuous straight joints are avoided by using small stones called *snecks* to break joint.

Regular Rubble in Courses. This is the most highly finished type of rubble walling. The stones are squared with hammer and chisel and all corners are brought to right angles, only the back being

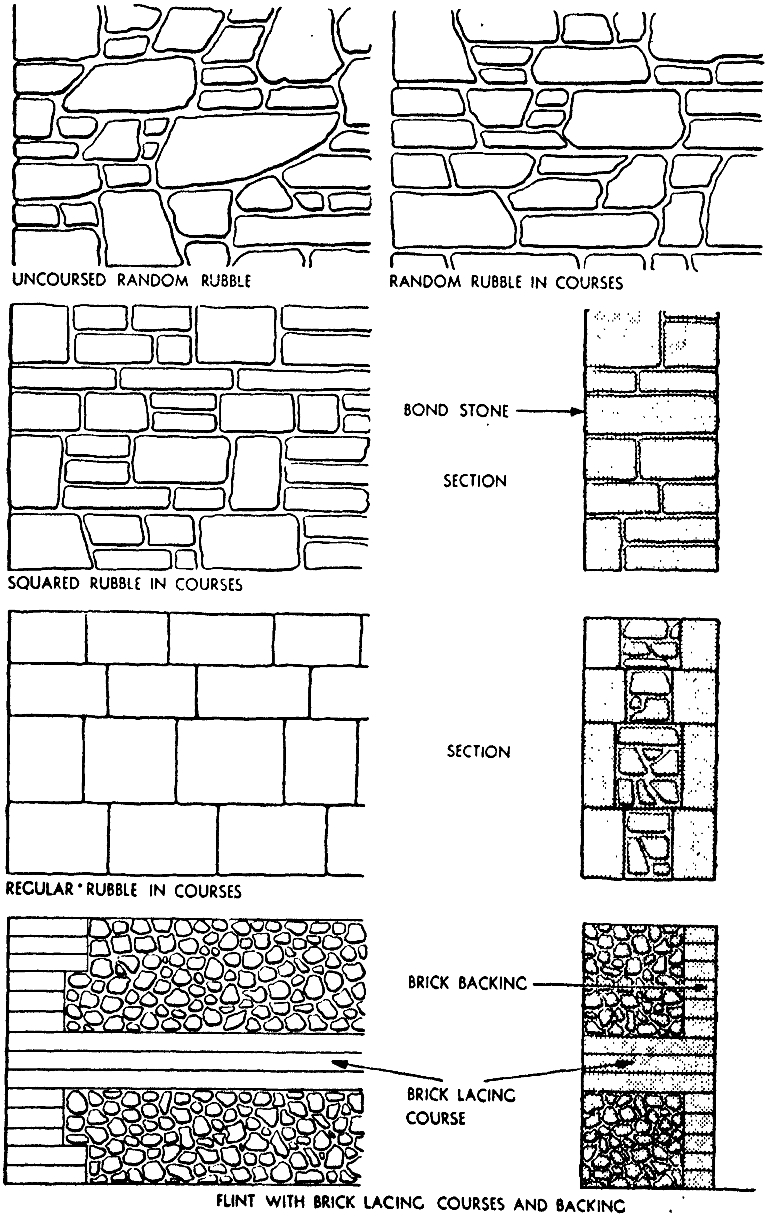


Fig. 5. Principal varieties of rubble walls. The rubble may consist of rough pieces of stone used as they come from the quarry, or alternatively, the stones may be worked to bring them to any required rectangular shape.

left in the rough. The stones are then graded for thickness. They are laid in straight courses, stones in each course being of even thickness, but some courses are comparatively thick and some thin. The interior of the wall is filled with small stones and grout, as with other rubble walls.

Flint Walling. In districts where flints are found flint walling is quite common. The flints are rather small, hard stones, dressed or *knapped* with the hammer to the required shape. They are often used in conjunction with courses of squared stone or brick and vertical stone posts.

Brick-Backed Rubble. A composite form of walling which is now used in the stone districts for houses and other buildings. As already explained, it is a cheaper and better type of wall than the all-rubble wall, and the good surface the brick backing gives for interior plastering is a great advantage. For houses the wall may be about 12 in. thick or a little more. Brick backing 4½ in. thick with stone facing 9 in. thick (total thickness 13½ in.) is often convenient.

The brick backing has a header course every six courses. This bonds into the stonework. The interior should be packed with flat rubble and grout, or *hearting*, as it is called. In tall or long walls the bond can be strengthened by placing a bond stone, the full thickness of the wall, to every square yard or so.

Ashlar. This highly finished masonry consists of stones accurately formed with plane surfaces and true right-angled corners and is used, generally, with brick backing.

Natural stone is found in layers or laminations, and in most stones this is revealed by the fine parallel lines on the faces of a block. It is important to lay wall stones in walls so that the layers or strata are horizontal, as in Fig. 6. If a block is laid with the strata vertical, the surface will probably spall off. In repair work it is sometimes found that a few blocks have decayed while the majority are quite sound. This may be due to the defective blocks having been laid the wrong way, possibly because the strata do not show clearly on the stone surface.

In stone arches the bed joints are not horizontal, they are on the radial lines passing through the arch centre. The direction of strata should be as parallel as possible with the bed joints, though, as the arch stones, or *voussoirs* as they are called, are wedge-shaped, this obviously is not quite attainable.

Stone mullions in windows should have the strata horizontal. The stone should be taken from a deep bed in which the material has no weak cleavage lines.

From these examples it will be understood that stone should be laid with the load bearing in a direction at right angles to the direction of strata.

Any flaws or weaknesses in stone will probably cause trouble. All defective stones should, therefore, be rejected. In repair work perfect stones must be selected, otherwise the new stone may soon develop defects.

Mortar for stonework should approximately match the stone in strength and density. Strong cement mortars are not usually desirable. The Building Research Station specify three mixes. No. 2, a moderately strong mix, consists

of 12 parts fine crushed stone (by volume), 3 parts lime putty or hydrated lime, 1 part Portland cement.

The question of efflorescence has already been dealt with in considering brick walls. The free salts which produce the characteristic white deposit may be present in Portland cement, so that a mortar with a small proportion of cement is much less likely to cause efflorescence than a comparatively strong mix.

In brick backings to stone facings, or rubble backing to large stones, a stronger cement should be used in the backing.

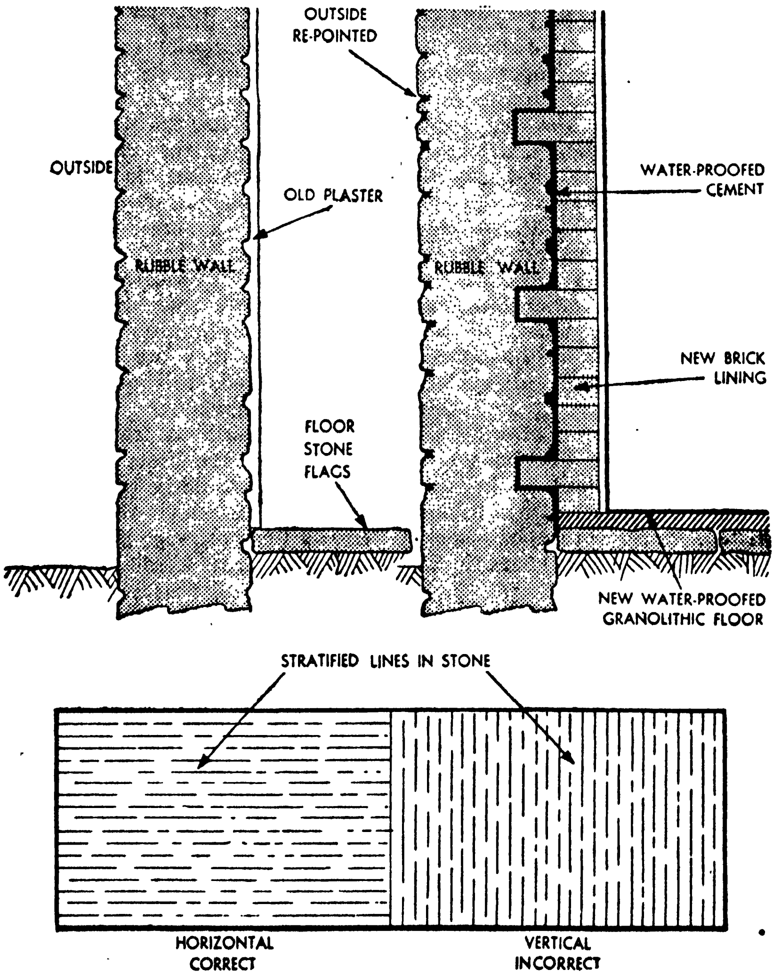


Fig. 6. (*Top*) Method of repairing an old rubble wall. (*Bottom*) Correct and incorrect methods of laying ashlar stones. They should be laid so that the strata are horizontal, and this is indicated by the fine parallel lines on their surfaces.

Otherwise, as there are many more bed joints in the backing, the settlement will be greater, and this may cause fractures in the wall.

In masonry large ashlar blocks have joints about $\frac{1}{8}$ in. thick. In rough rubble walling the joints vary from $\frac{3}{8}''$ upwards, being as much as 1 in. thick in places.

When fixing ashlar, screeding irons, which are strips of metal of joint thickness, are laid on the stones already fixed and are temporarily secured with mortar along each edge. The mortar bed is then spread and screeded level with a straightedge. When the mortar has begun to set, the irons are lifted, the space made good with mortar, and the stone lowered into position. By this method the mortar bed will not squeeze out.

Other than construction faults, the common defect in stone walls is general surface decay. This is due to soluble salts deposited in the surface skin, either by chemical attack in a polluted atmosphere or by the presence of such salts in the walling materials. The effect is to disintegrate the surface material.

Methods of Preservation

Although many chemical treatments are on the market, it is now recognised that the best treatment is cleansing with clean water or steam. The Building Research Station state: "Liberal washing with clean water, and nothing else, is calculated to remove the salts by solution, and periodical treatment in this way is the best known method of keeping natural stone in good condition, as well as enhancing the good appearance of the building."

For a stone surface which is badly grimed steam treatment, which is undertaken by specialist firms, is better than risky chemical cleansing agents which may accelerate rather than arrest decay.

In some cases when the surface has been washed over twice with plenty of clean water, grime may be brushed off. A further washing will then leave the surface reasonably clean.

Badly decayed stone should be removed and made good with stone from the same quarry. The mortar which has already been specified for stonework should be used. A strong cement-mortar introduces soluble salts which may produce decay.

Large stones with decayed patches may be repaired by cutting away the loose material and forming a key by hacking the back of the cut-out patch and undercutting the edges, as in Fig. 7. Make good the surface with mortar, using clean crushed stone as the aggregate, and finishing with a wood float, imitating the texture of the surrounding stone as closely as possible. Coloured pigments can be incorporated if required. A cement-lime mix, as specified, but with $1\frac{1}{2}$ parts of Portland cement, is quite strong enough for use with stones of moderate density.

Damp Walls

As the ground around the foundations is always damp, moisture is drawn up the walls, and unless a dampproof course is placed just above ground level the moisture will make the interior walls and floors damp The principal d.p.c. (common abbreviation for dampproof course) in a building is placed in all walls at least 6 in. above ground level and between the ground and the ground floors, as in Fig. 8 A.

Common Defects. Unfortunately this horizontal d.p.c. is often placed nearer the ground than the 6-in. clearance required by the by-laws. If the ground slopes it may rise above the d.p.c. on the high ground. When the garden is dug the soil is sometimes heaped back against the wall, and this may cover the d.p.c. In wet

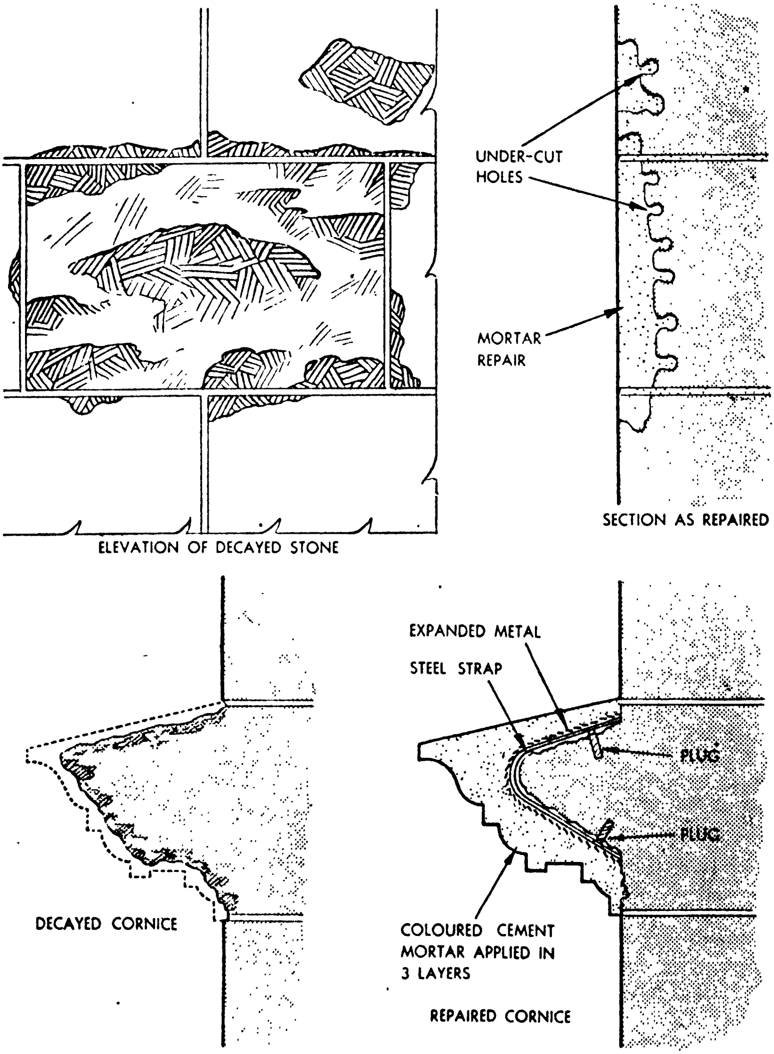


Fig. 7. Repairing decayed stonework. Loose material is cut away and a key formed by hacking the back of the cut-out patch and undercutting the edges. The surface is made good with mortar and finished off with a wood float.

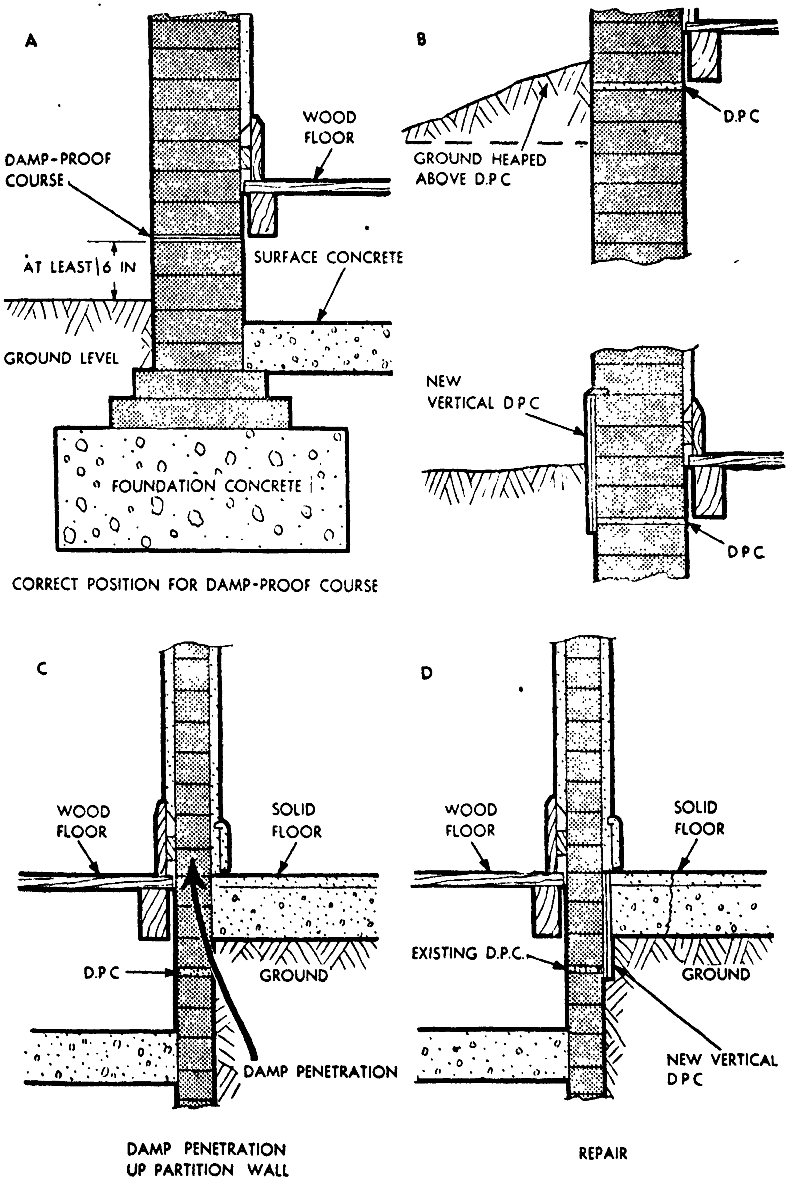


Fig. 8. Various positions for dampproof courses. *A.* D.p.c. between ground and ground floors and 6 in. above ground level. *B.* Vertical d.p.c. *C.* A common defect; the d.p.c. is several inches below the concrete, thus allowing damp to pass through the unprotected gap. *D.* Method of repairing defect shown in *C.* This is done by cutting out the concrete floor and placing the new d.p.c. in the position shown.

weather moisture may be drawn into the wall from the soil above the d.p.c. This is a common defect, and where dampness appears on the interior wall face near the floor the ground level in relation to the d.p.c. should be examined.

If the ground cannot be lowered to give the required 6-in. clearance, a vertical d.p.c. should be built, as shown in Fig. 8 B.

Another common defect is illustrated in Fig. 8 C. A partition wall with a solid floor on one side and a joist floor on the other has the d.p.c. a few inches below the concrete. If the ground is saturated with water, damp can rise through this unprotected gap. To repair the defect it is necessary to cut out the concrete floor against the wall and place a vertical d.p.c. to give full protection, as shown in Fig. 8 D.

Cavity Walls

Basements need a vertical d.p.c. to make the walls waterproof. An old method of waterproofing was to build a cavity wall around the basement so that moisture could not penetrate. Unfortunately many of these old cavity walls were carelessly built so that mortar droppings fell into the cavity, and moisture therefore penetrated. In any case water tends to drain to the bottom of the cavity, from which it may rise up the interior wall. In such a case the remedy indicated is to render the interior wall face with waterproofed cement.

A modern method of damp-proofing basements is to build the walls in two thicknesses with a vertical d.p.c. sandwiched in between. To cure a damp basement render inside, or outside, with waterproofed cement as in Fig. 9.

In old buildings walls may have no d.p.c. On a dry site on high land this may not matter much, except in very wet weather, but on most sites it will make the walls very damp inside.

One remedy is to cut out a course of bricks or stone, removing short lengths at a time, and inserting a d.p.c. of slates in cement-mortar, going all round the walls.

Underpinning

If the wall is badly decayed near ground level, with possibly defective foundations, a very sound job can be made by underpinning in short lengths, as in Fig. 9 A, using waterproofed concrete for the new foundation, and placing a vertical d.p.c. on the outside wall face. This method is, however, costly.

While it is usually best to place the new vertical d.p.c. against the outside wall face, it may sometimes be easier to fit it against the inside face.

Copings and Chimneys. The top of a wall which is not covered by a roof should be protected with a coping. A stone or pre-cast concrete coping should have a weathered top, as in Fig. 10. This slope throws the water off. The coping should be throated on the underside of the projection so that water will drip off and not run down the wall face.

If the coping material or its joints are defective water will soak down the parapet and appear on the ceilings or the inside wall face below. If the joints are faulty but the coping stones sound it may be sufficient to re-set the coping in waterproofed cement-mortar.

With a parapet wall in an exposed position, as in Fig. 10, it

is usually necessary to have a horizontal d.p.c. just above the roof gutter, as shown. This will prevent water soaking down the wall. Where dampness is due to the lack of this d.p.c. it may be advisable to take down the parapet and re-set the coping just above

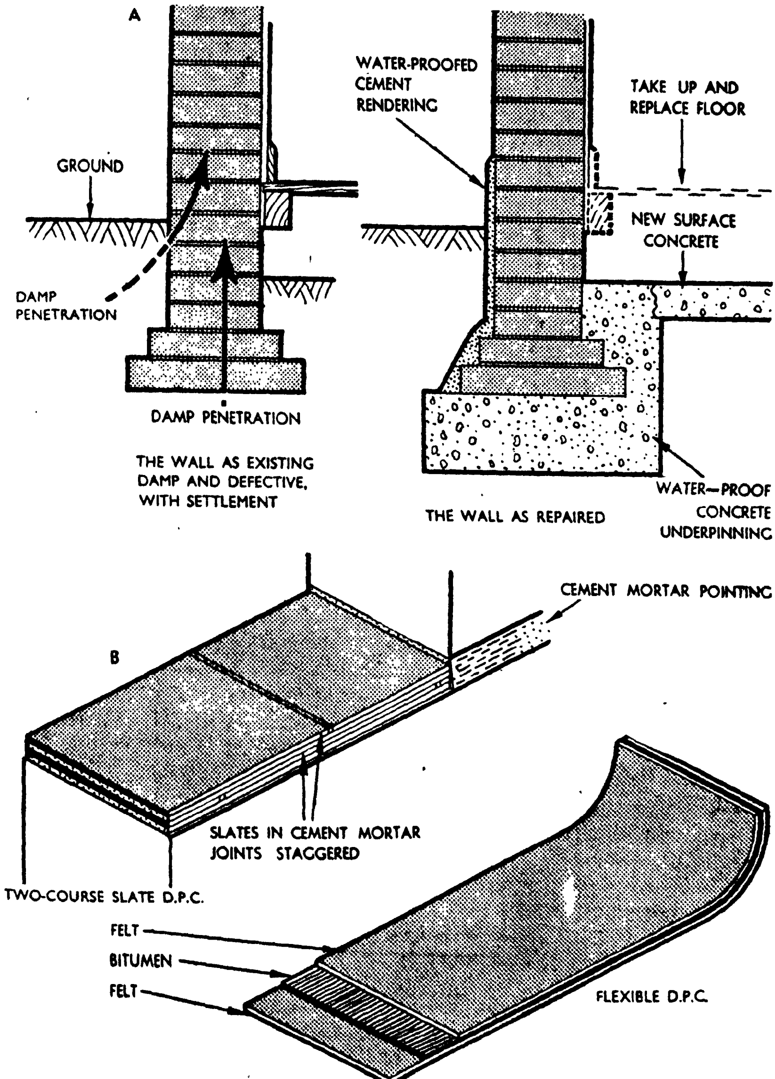


Fig. 9. A. (*Left*) Old wall with no d.p.c. and defective foundation. (*Right*) Wall repaired by underpinning with waterproof concrete and placing a vertical d.p.c. on the outside of the wall. B. Examples of rigid and flexible d.p.c.'s.

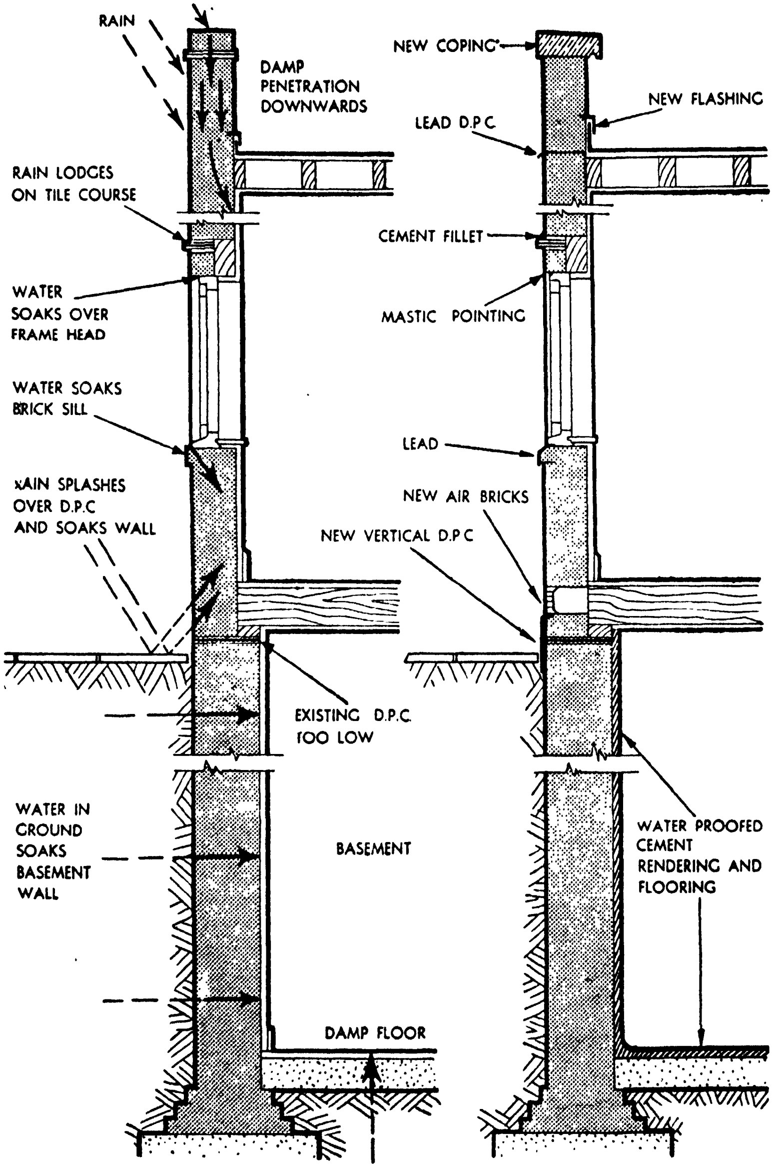


Fig. 10. Treatment and repair of defective wall details. *(Left)* **Wall as existing and** *(right)* **the same wall after it has been repaired. Note the horizontal d.p.c., which prevents water from soaking down the wall. The new coping has a weathered top and is throated on the underside to enable the water to drip off.**

gutter level, using waterproofed cement mortar.

Any durable waterproof material may be used to form a d.p.c. The chief materials used are natural slates of sound quality set in a mortar of Portland cement and clean sand, 1 : 1 mix. Two courses of slates should be used, each separately bedded, the joints between slates occurring over and under the middle of the slates below or above, as in Fig. 9 B. The mortar must not be allowed to dry too quickly or it may shrink and crack. When inserting slates in an old wall the existing brickwork or stonework must be well wetted.

In repairing old walls near and below ground, it may be convenient to use blue or other impervious engineering bricks set in cement mortar.

Waterproofed Portland cement-mortar is useful for vertical d.p.c. and renderings. A dependable waterproofer should be used, such as Pudlo, Lillington's Liquid, Cementone and Colemanoid. Certain cements are available which contain integral waterproofers.

Bitumen sheeting and bitumen-felt d.p.c. are flexible and are supplied in rolls of standard wall widths. These materials are durable but may be punctured by sharp grit or tacks, so they should be handled with care. Joints should be sealed with hot mastic.

Asphalt is durable but may squeeze out under heavy pressure. It is good as a vertical d.p.c. for dampproofing basements. It should be applied by specialist workmen.

Lead sheet, supplied in rolls of wall width, though durable under most conditions, may be attacked by chemicals in the mortar. It is obtainable sandwiched between bitumen, in which form it makes a first-class d.p.c.

Copper is also used as a d.p.c. Under copings and sills it has the advantage of taking up little thickness.

Types of Materials

The dampproofing materials just described can be divided into two types: rigid or brittle materials like slates in cement and blue bricks, and flexible materials like bitumen-felt and asphalt.

The rigid materials tend to fracture if stressed by unequal settlement of the wall. The flexible materials readily adjust themselves to small settlements, but may squeeze out under heavy pressure, and may also be punctured by careless handling and storing. Both types are sound if properly used in positions for which they are suitable.

In repair work the faults mentioned should be looked for. Fractures in slate or brick d.p.c. can be repaired by removing the bricks above to expose the surface of the d.p.c. and then grouting with waterproofed cement-mortar, replacing the surrounding bricks, and setting in waterproofed cement mortar. The flexible materials can be repaired with bitumen-mastic, of which there are a number of dependable kinds available.

Dampness in a building is a grave defect. It will cause dry rot of wood floors and other woodwork, general decay of the walls with disruption and spalling of plaster, and it ruins decorations. It also enables frost to disintegrate brick and masonry by expansion. Apart from the structure, it has a very detrimental effect on health.

Causes. In many cases it is not easy to trace the cause or causes. A thorough survey should be made of the building, inside and out, taking all factors into consideration, and remembering that moisture can travel a considerable distance before revealing itself inside the building. The patience and imagination of a detective are necessary to solve some cases, also of course a good knowledge of general construction and possible sources of trouble.

The chief causes of dampness are: (1) rainwater soaking through the walls, possibly through the walling material being excessively porous or the joints defective, or through the wall being in an exceptionally exposed position; (2) defects or leakage points in flashings, window and door frames, sills and jambs; (3) defects in, or absence of, d.p.c.; (4) defects in roofs, copings and parapet walls; (5) condensation.

Drying-out

In a new building drying-out may be mistaken for dampness. The moisture contained in walls and plaster is often considerable, especially if the building was erected during a period of wet weather. If the weather continues wet it may take some time for the walls to dry out. In the meantime fires should be kept going in the rooms and the windows kept open. Under unfavourable weather conditions it may take twelve months for a building to dry out.

If the dampness appears in extensive patches on one or more walls, and it is impossible to find any gaps around windows or any defective flashings, and the d.p.c. is considered to be sound and correctly positioned, then it is probable that rainwater is soaking through the wall. If the damp wall is exposed to the south or west, from which directions the rain-bearing gales blow, this is additional evidence. Fig. 10 illustrates some common points at which damp penetrates.

Locating Damp Penetration

First, closely inspect the walling material. Fine cracks and fissures are evidence of poor-quality bricks. Water is drawn through fine fissures by capillary attraction. Stone with coarse grain contains open pores into which water may be drawn.

If the walling material appears to be sound and not excessively absorbent, examine the joints, cutting away some of the pointing if necessary. Shrinkage in strong cement-mortars is one source of dampness. Fine fissures may open between mortar and brick or stone. Water will be drawn into these fissures.

General decay of the outside wall surface will be fairly obvious; for the moment the apparently sound wall with excessively absorbent material or poor joints will be dealt with.

If it is considered certain that the wall is excessively absorbent, a treatment to suit the cause must be selected. If the joints or pointing are defective, re-pointing with a cement-lime-mortar should effect a cure. If the bricks or stones are excessively porous, an all-over waterproofing treatment is necessary.

Waterproofing Liquids. The cheapest treatment, and the one which will have least effect on the appearance of the wall, is treatment with a waterproofing liquid.

Two or three applications of boiled linseed oil, *when the wall is dry*, is an old-fashioned treatment. It may be effective for a time, but the oil will gradually evaporate.

Treatment with a waterproofing liquid is better. But even so, it is doubtful whether any liquid provides a permanent cure in a really bad case, unless it is renewed every three or four years. Any liquid treatment should only be applied when the wall is dry, and the wall brushed down afterwards to give it a clean surface.

Methods of Application

There are several good waterproofing preparations, but it is important to select one suitable for the particular wall material and condition. The effect of such treatment may be to fill the surface pores, or to coat the surface with a water-repellent film. Most of these liquids are colourless, but tend to darken the tone of the walling. Particular ones are suitable for brick, concrete or stone. They must be brushed well into the surface, and two or three applications may be necessary.

Most can be sprayed at a pressure of about 20 lb. per sq. in. but they should be used strictly in accordance with the makers' instructions.

In addition to colourless liquids there are certain bituminous compositions. R.W.I. Marine Cement is one. This is a black asphaltum composition which can be applied to interior or exterior surfaces by brush or spray. It provides a good bond for plaster or cement rendering. Two coats are applied. The colour is black, but as an undercoat for plaster or cement this is no disadvantage.

Some waterproofers for surface treatment are supplied in the form of powders or pastes. Stet is a dry powder which can be mixed with water and applied by brush or spray. An important point about Stet is that it can be applied to a damp surface. It becomes part of the surface and effectively seals all cracks and small holes. It is made in a range of colours, and, of course, conceals the original surface.

External Renderings. A cement-sand rendering is indicated if the walling material is very porous and in bad condition. It is advisable to add a waterproofer to the mix, and if the walling is in a very exposed position this is essential.

It does not matter how rough the surface of the wall is, as long as the surface is firm. There must be no progressive movement, flaking, or decay of the wall under the rendering. If there is, the rendering will be disrupted. The first step is to cut out all soft decayed material and get down to a firm surface. Rake the joints out, and then wash and brush down the wall so that there is no dust or loose material left. If the wall material is smooth it should be hacked to provide a good key. The adherence of cement or plaster to smooth surfaces is poor. Raking the joints out will provide sufficient key with brickwork.

Using Expanded Metal

If the walling material is so soft and badly decayed that a firm surface cannot be provided, it should be covered with expanded metal. First fix steel rods to the wall with strong staples. These rods should be fixed at intervals and patent wall plugs used if the walling is very soft.

Tie the expanded metal to the rods with iron wire. This provides not only a good key, but also a metal reinforcement. In effect the rendering forms a facing sheet of reinforced concrete.

Walls which show considerable efflorescence may not hold cement rendering or plaster, as the salt deposits behind the rendering may force the rendering off in patches. The use of expanded metal will prevent this. Another method in such a case is to drive galvanised nails into the bed joints, leaving the heads projecting. This provides an excellent addition to the key. If waterproofed cement is used the salts will not pass through the rendering, but this will naturally increase the disruptive force behind the rendering.

Choice of Mix

External renderings should not be too strong, or they will shrink and crack. A mix recommended by the Building Research Station is:

Undercoat (*parts by volume*): 3 parts white hydrated lime or stiff lime putty; 1 part Portland cement; 10 parts clean sand or crushed stone aggregate.

Finishing coat: 3 parts lime as above; 1 part Portland cement; 12 parts sand or crushed stone, according to colour and texture required.

If lime putty is used this may be knocked up into lime-sand coarse stuff, and the cement added before use. All material should be used within about two hours from the time the cement is added.

Where the walls are in positions of severe exposure to driving rain a cement-sand mix is recommended for the undercoat, finishing in a cement-lime-sand mix.

Faults in external renderings may be due to a weak wall surface, as already explained, to too rich a cement mixture, or to excessive use of the trowel or float. The latter produces a rich cement skin on the surface. This skin shrinks, and surface crazing results. Finish with a wood float for a smooth surface. For a rough texture wipe with sacking.

Rough-Cast. Finish is produced by throwing pebbles or gravel on to the rendering while it is still *green*. Green rendering, or concrete, is material which has not set. The rough-cast material is liable to fall off unless thrown on with some force. This should follow the rendering within half an hour. The impact improves the adhesion by removing air pockets, so that rough-cast rendering is less liable to develop faults than plain rendering.

White cement and various coloured mixtures can be used for coloured renderings.

Waterproofers

Waterproofers are specially made for incorporation in the undercoat. The effect is to close the pores and make the rendering impervious. There are many brands, some of which have been mentioned. Some are liquids and some powders. They should be used strictly in accordance with the makers' instructions. In applying a rendering as a cure for dampness in decayed or very porous walls it is advisable to use a waterproofing admixture.

If the exterior wall face consists of costly facing bricks or stone in good condition, the dampness being due to excessive porosity, it is objectionable to conceal such work with an exterior rendering.

An *interior rendering* with a waterproofing admixture can then be adopted as a cure for dampness. Two $\frac{3}{8}$-in. thick renderings making a total thickness of $\frac{3}{4}$ in. are usually sufficient. Old plaster must be completely removed and the joints raked out. To avoid condensation, finish with a wood float, or with a skimming coat of lime plaster.

Waterproof Paints

Any durable waterproof paint can be applied to the exterior wall face as a cure for dampness. One such paint—Stet—has already been described. Black or red bituminous paints can be used, but the colours are not pleasing. A good oil paint looks well, if renewed every four or five years, but this is not a cheap treatment. The wall must be dry when the paint is applied, and a priming coat of petrifying liquid must be applied to stop suction and to prevent the action of free salts contained in the wall on the paint. In an old wall there is much less danger from free salts than in a new one.

Cavity Walls in houses consist of two $4\frac{1}{2}$-in. thick walls separated by a cavity 2 in. or $2\frac{1}{2}$ in. wide. The two walls are tied together with metal ties. The cavity should extend below the d.p.c. The d.p.c. should, therefore, be in two portions separated by the cavity. Details of sound practice are illustrated in Fig. 11.

A cavity wall is dampproof if it is properly designed and built. Unfortunately faults are rather common. If the cavity finishes at the d.p.c. level, water will accumulate at this level and make contact with the inner wall. Moisture will then be absorbed by this wall and dampness will appear near the floor.

Mortar droppings often accumulate on the ties. The effect of this is to bridge the cavity with absorbent material, so that damp can creep across to the inner wall, and will then appear in patches on the inside face.

The above faults are difficult to cure, since the cavity cannot be reached without opening up the wall—a costly operation. It is usually best to treat the dampness as already described for solid walls.

Sheet lead should be placed over the window and door frames to prevent water soaking across the window head and lintel. This lead should be carried through the outer wall, or over the head of the frame as shown in Fig. 11. If this lead is absent and damp appears over the window on the inside wall face, the remedy is to cut out the bricks over the window, on the outside face, and fix lead as shown. Project the ends of the sheet about 6 in. beyond the head of the window frame so that water collecting on the sheet will fall clear into the cavity. The sheet lead must be turned up against the inside wall.

If it is desired to clean a cavity of mortar droppings, open the end of the wall so that a lath or rod can be passed into the cavity and the mortar raked out. Obviously this can be done only with a rather short wall.

The window and door jambs should be formed by one of the methods shown in Fig. 11. A vertical slate d.p.c. is fixed here to prevent moisture reaching the inner wall. A common fault is to build the jamb in solid brickwork without a vertical d.p.c. The

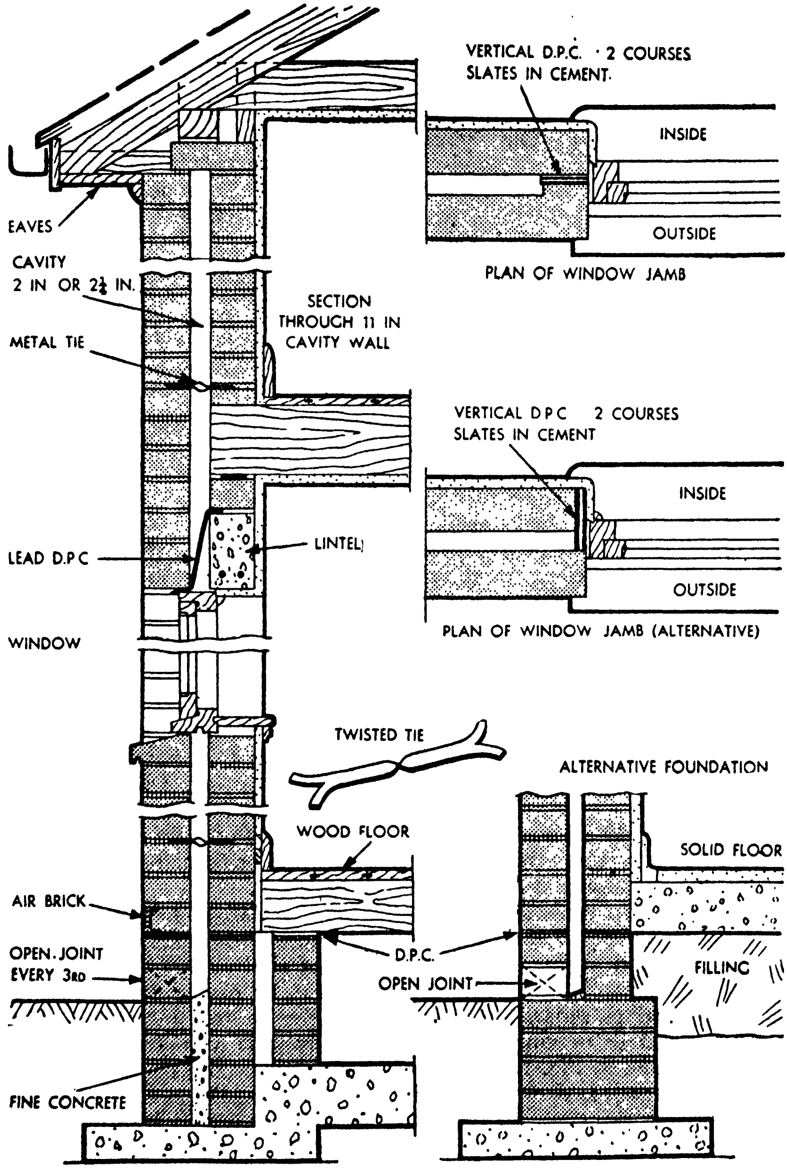


Fig. 11. Details of sound practice in cavity-wall construction. Sheet lead is placed over window and door frames to prevent water soaking across window head and lintel; this lead should be carried through outer wall or over the head of frame as indicated. The methods of forming window and door jambs are shown, and also the position of the d.p.c. to prevent moisture from reaching inner wall.

appearance of damp around the inside jambs is an indication of this, provided that water is not penetrating between frame and jamb. The remedy is to open the jamb and insert a vertical d.p.c. A cheap alternative is to treat the brickwork around the door or window opening with a liquid waterproofer, but this is not a definite cure.

Leakage Points

Under this head leakages around door and window frames, ventilators and eaves, may be considered.

Water often penetrates between frames and jambs. The precautions commonly adopted to prevent this are not effective in an exposed position. Ordinary mortar opens a fissure; wood mouldings do not make perfect contact with the wall, and the trouble is aggravated by shrinkage of wood frames.

One remedy is to fix wood moulding strips, preferably of hardwood, bedded against the wall in putty or thick paint. Another is to point with a mastic material which will not shrink. Special mastics are made for this purpose. A third remedy is to cut strips of lead of suitable thickness, filing one edge to a bevel, and forcing it gently into the gap.

Water running down the wall sometimes penetrates the window or door head. The best remedy, after closing the gap between frame and wall, is to fix a lead hood flashing over the arch or window head. The edge should project, preferably over a hardwood moulding; the water will then drip off.

The eaves of the roof are sometimes defective. If the beam-filling between rafters which have the feet exposed is not perfect, driving rain may penetrate and soak down the wall. The remedy is to point up the beam-filling. If the roof covering is defective, water will run under the roof to the eaves and soak the wall.

Boxed eaves, with soffit and fascia boards, sometimes have open gaps caused by bad workmanship or shrinkage. The gaps can be filled by fixing small mouldings.

A good overhang to the eaves, say 12 in., gives excellent protection to the wall. This protection is absent with walls terminating in a parapet. The importance of making the parapet watertight cannot be overstated. If the wall is damp, see to the parapet first. Make the coping watertight and point up the brickwork if necessary. Treating the parapet wall with a waterproofing solution, front and back, will sometimes cure the trouble.

Tile and Slate Hanging

Tile and Slate Hanging is an old and effective remedy for damp walls, but it is costly, and the waterproofing solutions and waterproofed renderings already described are usually preferred. Details are illustrated in Fig. 12.

On an existing brick or masonry wall vertical counter-battens are first fixed; these are $2 \times \frac{3}{4}$ in. secured to wall plugs and spaced at 14-in. centres. Then the horizontal tiling laths are nailed to the battens. The laths are $1\frac{1}{2} \times \frac{3}{4}$ in. Both battens and laths should be treated with wood preservative. The laths are spaced to suit the gauge of tiling.

There are two plain clay tile sizes: $10\frac{1}{2} \times 6\frac{1}{2}$ in. and 11×7 in. A lap of $1\frac{1}{2}$ in. is usually sufficient for tile hanging, but in exception-

ally exposed positions a 2-in. lap is advisable. The gauge is the distance from tile edge to tile edge as showing on the face. With a 2-in. lap, using $10\frac{1}{2}$ in. tiles, the gauge is $4\frac{1}{4}$ in. The tiles should have nibs to hang on the laths, and they should be nailed with zinc, copper,

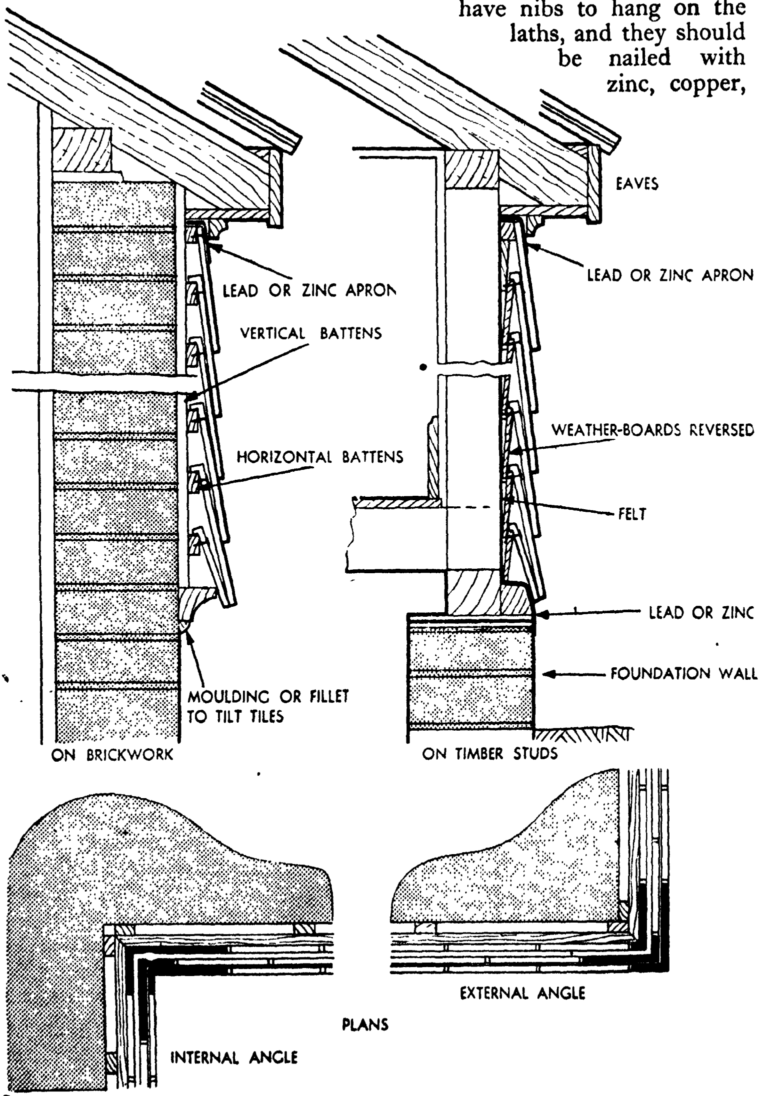


Fig. 12. Method of tile hanging to cure dampness in existing walls. Wall tiling is usually carried down to the level of the ground-floor window heads, but if it is designed to cover the whole wall, the tiles should finish approximately 15 in. above the ground level. The lowest course is tilted by fixing a fillet to the wall.

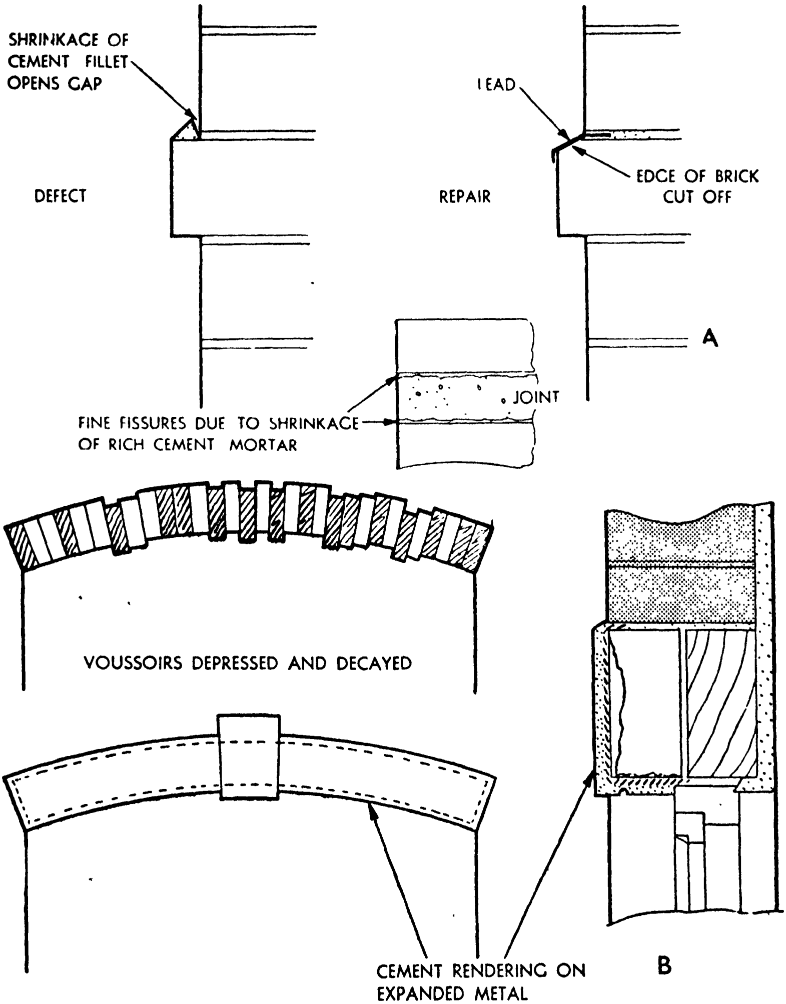


Fig. 13. A. Water lodging on projecting string course and fine fissures in mortar joints. *B.* Repairing a decayed arch in which voussoirs have slipped down their beds. Voussoirs are repaired by having all loose material cut away and then covered with painted expanded metal and rendered over with cement mortar.

or composition nails. Galvanised nails are not durable. Composition nails are best.

The wall tiling is usually carried down to the level of the ground-floor window heads, but if it is necessary to cover the whole wall they should finish about 15 in. above ground level. The lowest course should be tilted by fixing a fillet and soffit as shown in Fig. 12. External and internal angle

tiles, forming an angle of 90 deg., are specially made for corners though plain tiles may be mitred at the angles. Zinc or lead soakers should be used at internal angles with mitred tiles. Verges at window reveals should be finished as in roofing practice, finishing the reveals with rendering.

Condensation. Moisture forming on interior wall faces, as distinct from damp penetration, is condensed from the atmosphere. A cold impervious wall face tends to condensation, as also does poor ventilation. Portland cement and hard smooth wall linings offer surfaces on which condensation readily takes place. The remedy is to provide a rather rough textured and absorbent wall lining. Thus, a hard impervious plaster should be hacked off and a skimming coat of lime plaster applied, finishing with a wood float. Fibre board is sometimes fixed to cure the trouble, but condensation can often be cured by providing better ventilation

Defects in Arches

Slight defects in arches, such as decayed joints and spalling of the surface, may be treated as already described. Badly decayed arches in which some voussoirs have slipped down their beds, as shown in Fig. 13 B, should have all loose material cut away, and then should be repaired by covering with painted expanded metal and rendering over with cement mortar. But if the arch has settled and cracked it is in a dangerous condition. The brickwork above should be underpinned while a new arch or beam is inserted.

If slight joint cracks appear over a beam, excessive deflection of the beam is indicated. This may not be dangerous, but the cracks should be pointed.

Extensive cracks and bulging in walls indicate settlement of the foundations or very extensive decay. The cause should be traced and remedied. Defective foundations should be underpinned with new concrete. Bulging walls should be strengthened with steel tie-rods, with timber or steel plates running horizontally or vertically over the outside wall faces, as shown in Fig. 14.

To test cracks for continued movement, place dabs of cement-mortar at intervals over the cracks, as in Fig. 14. If the dabs are fractured after an interval, the continued opening of the crack is indicated. This is usually due to foundation settlement.

When repairing deep cracks the crack should be undercut to form a key, washed to remove dust, and repaired with Keene's, Sirapite, or Parian cement.

For re-plastering in large areas, entirely remove the old plaster, raking the joints to form a good key. Well wet the wall before re-plastering.

Three-coat work is best. The first or rendering coat and the second or floating coat consist of coarse stuff made by mixing 1 part of slaked lime to 2 or 3 parts of sharp sand. On lathing, 1 lb. of clean cowhair should be added to 3 cu. ft. of coarse stuff.

The fine stuff used for the setting coat is made with lime putty, which is the finest and most thoroughly slaked lime. Use 1 part lime putty to 1 part clean sand. The setting coat should be $\frac{1}{8}$ in. thick, making a total thickness of $\frac{3}{4}$ to $\frac{7}{8}$ in. Where it is considered desirable hard plaster may be used for the setting coat.

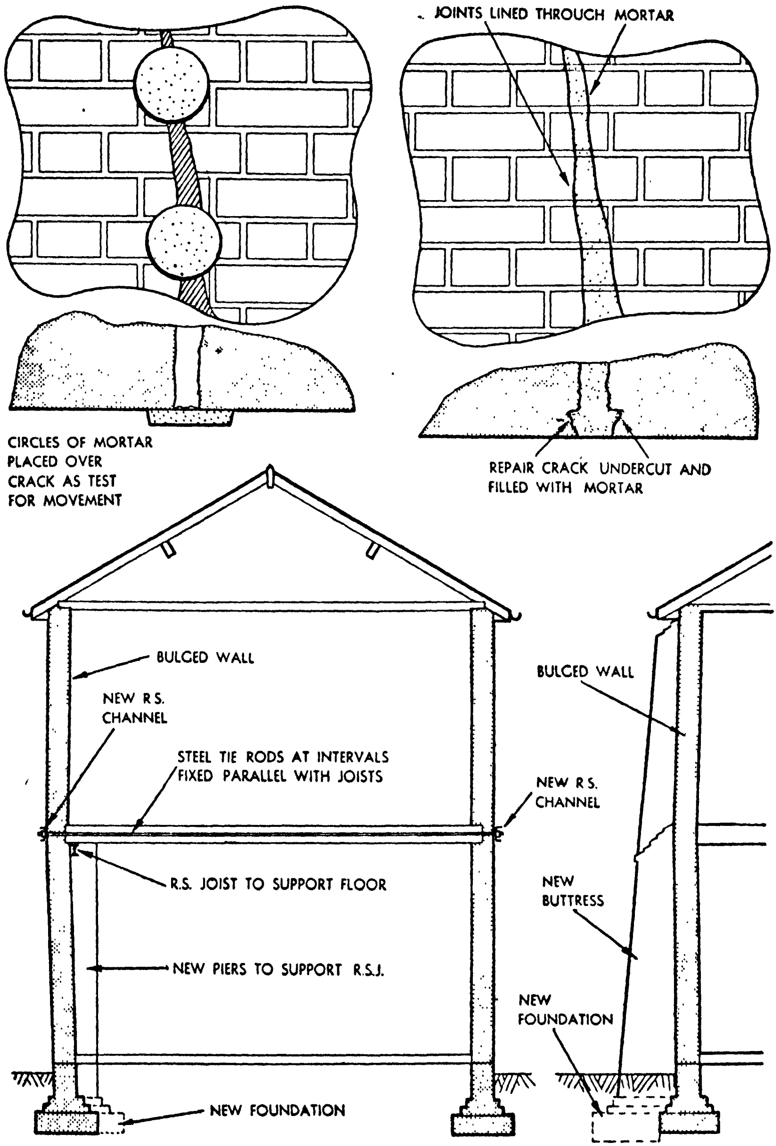


Fig. 14. Extensive cracks and bulging in walls. Walls are strengthened with steel tie rods, with timber or steel plates running horizontally or vertically over the outside wall faces, or buttresses are built. Testing for movement is carried out by placing dabs of cement mortar at intervals over the cracks. If, after some time, the dabs are fractured, the continued opening of the crack is clearly indicated.

CHAPTER 2

ROOF WORK

CLASSIFICATION OF SLATES. COLOUR. PREPARATION OF ROOFS. NAILS. METHODS OF SLATING. HIP FINISHES. REPAIRS TO SLATED ROOFS. TYPES AND SIZES OF TILES. SINGLE LAP TILING. ASBESTOS CEMENT ROOFING MATERIALS. GUTTERS. FLAT ROOFS. LAYING ROOF COVERINGS. ASPHALTS. COMPOSITE ROOF COVERINGS. APRONS, SOAKERS AND FLASHINGS. STEEL SHEETINGS. PAINTING IRONWORK. WATER PENETRATION.

ALTHOUGH now taking second place to tiles in popularity, slates provide the most durable roof côvering known, and if their architectural possibilities are combined with their utility value, distinction and character can be added to all appropriate classes of buildings.

Slates are quarried from natural rock, the principal deposits in Britain being found in North Wales and Westmorland and to a lesser extent in Cornwall, Cumberland, South Wales and Scotland. Stone slates are dealt with at the end of this section while manufactured slates of asbestos cement are described later under "Asbestos Cement Materials".

Classification. The general method of classifying slates is by reference to them as firsts, seconds and thirds, but this grading does not apply to quality, but to weights and thicknesses. Again, as these characteristics vary greatly in different localities, references cannot be said to convey any clear indication of the type of slate in question without being coupled to the source of supply.

Sizes range from 12 × 6 in. up to 24 × 12 in., the size used being governed firstly by the sound building principle that the size of the slate should rise as the pitch of the roof is lowered, and secondly to suit the architectural proportions of the buildings. Although the use of large slates on steep pitches is not bad practice, the use of small slates on low pitched roofs should be avoided.

Range of Colours

It is rather unfortunate that the very word "slate" brings to the minds of many people a vision of rows of dingy cottages covered with dirty grey squares. It seems that the indiscriminate use of slates by our Victorian predecessors on the grounds of cheapness, without any thought being given to appearance, has set up a certain bias against this form of roofing. In fact, however, the range of natural colours in which slates can be supplied is very wide. It includes greys, greens, blues, purples and reds, and where the desired effect cannot be obtained with natural colours, artificially coloured slates are obtainable in great variety.

Preparation of Roofs. The cheapest method of preparing a roof for slating is to nail timber battens, usually size 2 × ¾ in. or

1 in., direct to the rafters. Providing the pitch of the roof is not too low, this will give a reasonably water- and wind-tight job, the most serious disadvantage being the lack of insulating qualities. Slates are sometimes nailed direct to close boarding but this method is not recommended.

Slightly better, and advisable in all exposed positions and where the pitch of the roof is low, is the use of untearable felt. The felt should be laid vertically beneath the battens thus preventing creation of a water bar; and allowed to hang rather loosely across its width to enable any water to pass below the battens. Methods adopted for better-class work are boarding and battening, boarding felting and battening and boarding, felting, battening and counter battening, but of course these increase the costs considerably.

Prevention of Rot

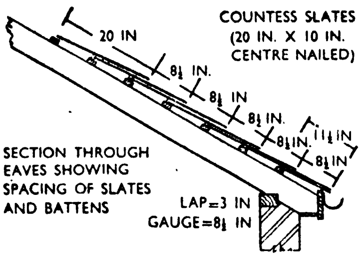
Two general points which are well worth noting in preparing roofs are (*a*) a roof which is battened only has the advantage of giving adequate ventilation to the roof space which is denied to a close boarded roof, but leaves a tendency for driving wind or snow to percolate through; and (*b*) where the additional cost of boarding as well as battens, is accepted it is a wise policy to go a little further and counter-batten, so as to allow any water percolating through the slates the opportunity of escaping at the eaves and thus avoiding the danger of rot setting up in the boarding and/or battens.

Nailing and Nails. Slates can be secured either by centre or head nailing, but generally speaking centre nailing is adopted as being the more economical and it also obviates the danger of lifting caused by wind pressure.

Nails may be zinc, copper or composition, but for all general purposes the composition nail is the best choice, being tougher than any other and easily driven, although on more expensive work copper nails are apparently preferred on account of their durability, bearing in mind that the life of any slated roof is governed by the lasting quality of the nails used.

Lap, Gauge and Margin (Fig. 1). Lap is the amount of cover a slate affords over the head of the slate two courses below; gauge is the dimension centre to centre of battens or nail holes; and margin is the length of slate left exposed when the course above is in position. In specifying slated roofs it is usual to indicate the size of slate coupled with the required lap rather than give the size of slate and gauge, thus ensuring consistent cover throughout. The lap used is determined to a great extent by the pitch of the roof, the lower the pitch the larger the lap required; but for general purposes a minimum of 3 in. is fairly safe.

Laying (Figs. 1 and 4). Roofs can be slated in various ways, the most common being as follows; (*a*) with slates of a consistent size throughout, this being the cheapest method; or (*b*) with random width slates, that is with slates of equal length but of varying widths, requiring greater care, but having the advantage of breaking the monotony of regular joints; or (*c*) with random-sized slates, that is slates varying in both width and length, these usually being laid in evenly diminishing courses



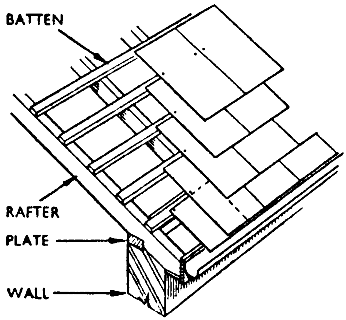


Fig. 1. Roof covering of "Countess" slates. Centre nailing is recommended for all slating. The minimum lap which should be used is 3 in. and the maximum gauge or margin should be 8½ in. Note the double course at eaves.

from large at the eaves to small at the ridge, giving a very pleasing appearance, but entailing a great deal of extra work in sorting and placing of the battens, and thereby raising the costs by a considerable amount.

Eaves (Fig. 1). In all cases a double course is laid at the eaves to maintain the minimum of a double thickness of slate common to all parts of the roof. This under-eaves slate is sometimes nailed to the first batten in common with the top slate, but it is considered much better practice to use a short slate nailed to an additional batten, or, alternatively, nailed to a tilting fillet so that the fixing is as near to the gutter as possible.

Verges. On cheap work verges or gables are often finished merely by the use of a slate and a half slate (*i.e.*, a slate 1½ times the width of those adjoining) laid every alternate course without any undercloak. The underside is then pointed up with cement and sand, but this leaves a very weak point for the weather to attack, and it is sound policy to provide for an under-cloak of a slate, or several slates, bedded in cement on the rake of the gable, to all verges. This under-cloak should be laid a minimum of 1½ in. proud of the wall face, and will provide a weather-tight joint, prevent water flowing off the verge by forming a tilt and enhance the appearance of the building.

Ridges (Fig. 2). The best finish for ridges on slated work has always seemed rather doubtful, the methods used being slate wings and rolls, wood rolls with lead dressings, and half-round or angular clay or concrete tiles. Of these the half-round tile appears to lead the field, but a very neat finish can be obtained by the use of an angular concrete tile coloured in manufacture to match the slating. Although these naturally cannot be a stock line, the slight additional cost is worth considering.

Hips (Figs. 3 and 4). The methods enumerated above for ridges are equally applicable to hips, but an alternative finish to hips largely used in better-class work is to close mitre. This finish, although the neatest possible, must be carried out with extreme care if it is to be successful, and is best avoided except on high pitches.

The mitred slates can either be bedded direct on to special mastic to weatherproof the joint,

or have soakers under, preferably lead, the latter being perhaps the better of the two. Where half-round tiles are used it should be remembered that hip irons must be fixed at the foot of the hip to prevent the tiles slipping.

Valleys. These can be formed with open gutters, or with close-mitred slates with soakers, or a secret gutter under or, alternatively, swept (*i.e.*, rounded with continuous slating). Open gutters are the easiest to construct and the most trouble free, but are rather unsightly. Where decided upon, it is advisable to use lead, and make the minimum width at any point 8 in., to allow foot room for carrying out repairs. Mitred valleys give a very tidy finish, and providing they are carefully soakered, should not be costly to maintain.

Secret gutters are mentioned as an alternative, but are not recommended, on the principle of never making inaccessible any part of a building requiring periodic attention. Swept valleys add greatly to the character of a roof, but are an expensive item. To keep the sweep of this type of valley within reasonable limits it is advisable to use narrow-width slates, the sweep being effected by laying boarding across the intersecting rafters, firring as required and battening. It is most important to ensure that the minimum lap used for the remainder of the roof is rigidly adhered to at this point.

Stone Slates (Fig. 5). Although providing an exceedingly attractive form of roof covering stone slates are seldom used on new works on account of the heavy weight of timber and strength of struc-

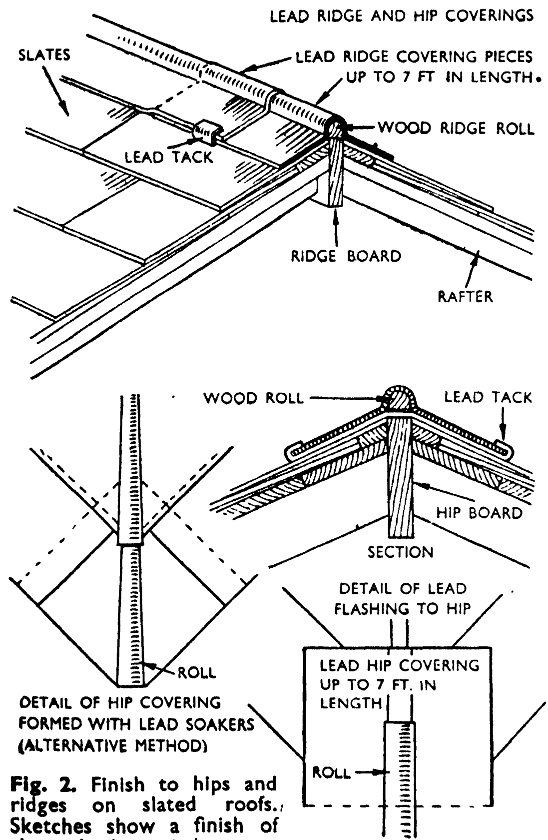
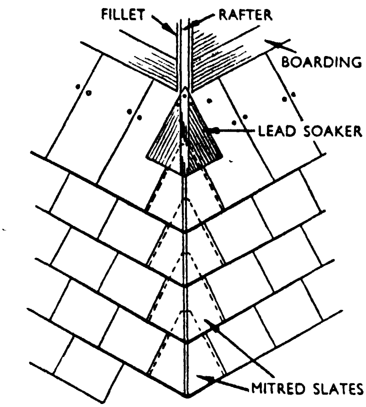


Fig. 2. Finish to hips and ridges on slated roofs. Sketches show a finish of sheet lead carried over a wood roll and dressed down either side. Half-round or angular tiles, natural or coloured to match the slates, are now generally used in preference to this method.



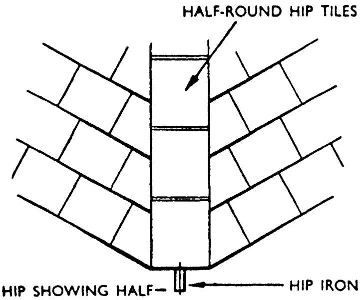


Fig. 3. Methods of finishing to hips on slated roofs. (*Top*) Close mitred hip with lead soakers under. (*Bottom*) Hip covering of half-round tiles. Note the use of hip iron at the foot of the hip to prevent the tiles from slipping.

tural work necessary to take the loading, but they may be encountered on alterations and/or additions to existing buildings. Thicknesses of the slates vary between $\frac{5}{8}$ in. or $\frac{3}{4}$ in. and 1 in., sizes range up to approximately 2 ft. (the largest size possible for reasonable handling) while the colours are natural and differing in accordance with the locality of their quarry. The common method of fixing is to normal slate battens on open rafters, plasterer's laths being laid between and parallel to the battens, and rendered with lime mortar solid to the top face of the battens. The slates are then bedded and pointed with stone mortar and head nailed. Laying is usually carried out in random widths or random sizes laid in diminishing courses. Ridges and hips are best finished with sawn stone angular cappings. If half-round clay tiles are used as an alternative, the larger sizes are preferable to maintain the strong outlines of this form of roofing. Valleys are generally swept, as open gutters rather break the unity and close mitring is not particularly easy. Eaves require a double course and undercloaks should be fitted to verges.

Cracked Slates

Trouble usually arises through slates slipping or cracking, the former generally being caused by the use of inferior nails in the first place. It may well be reiterated that it is essential to use strong and durable nails for all slating work. Cracking is caused by high winds lifting the slates without dislodging the nails, or by falling debris.

The method of repair is to remove all loose or cracked slates from the affected area, and also two courses of sound slates above this area. Having made up to the original number with sound slates of equal size, it is possible, where centre nailing has been employed, to work up from the bottom and nail fix every slate with the exception of one. This latter is firmly secured with a copper or lead clip, turned under the head of the slate below (or nailed to the nearest batten) and over the tail of the

last slate. Where head nailing is used, clips must, of course, be used for securing all the replaced slates in the highest course.

It quite often happens that a builder is called in to render a slated roof watertight when the condition of the roof is so bad that patching would be totally ineffective. In these cases a measure sometimes adopted, where reslating is out of the question on account of expense, is to cover completely the roof with a cement slurry of fairly weak mix and well worked into the interstices; but this remedy can only be expected to be of a temporary nature, as cracking of the slurry after a short time can hardly be avoided.

Emergency repairs are best effected by covering the defective or damaged area with roofing felt, allowing a generous margin either side, and holding in position with vertical battens, which will keep out the worst of the weather until permanent repairs can be carried out. To remove defective slates a "ripper" should be used, this being a slater's tool comprised of a wooden handled, flat metal bar ended with a shaped arrow head for inserting under the slate and hooking round the nail, which can then be drawn or cut.

Clips used for holding the final slate in position where only a section of the roof has been reslated are usually pieces of heavy-weight lead about ½ in. wide, or short lengths of stout copper wire.

Tiling

Tiles are principally manufactured from clay earth, both by hand and machine, the handmade tile being the better product. Machine-made concrete tiles are now used more frequently, and while they incline to lack

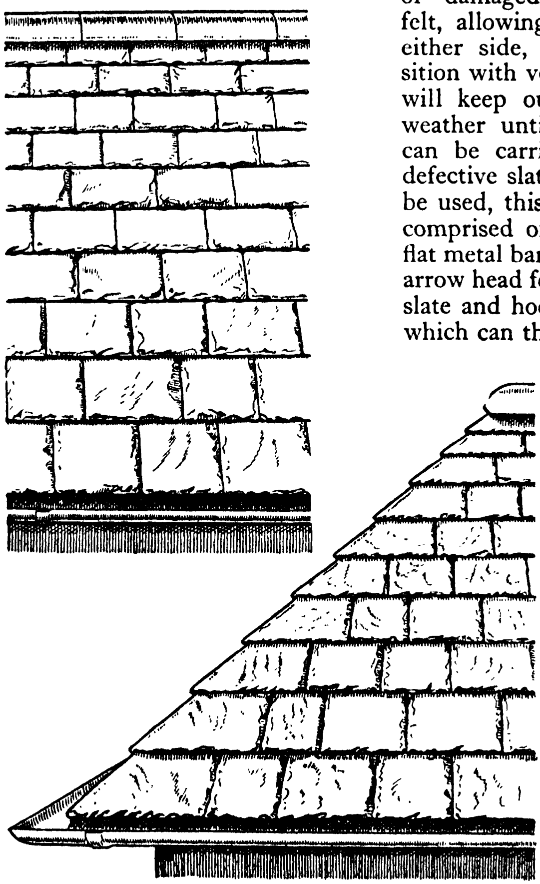


Fig. 4. Random slating. Sketches show the uneven widths and lengths of the slates, the courses evenly diminishing from large at the eaves to small at the ridge. Sketch (*bottom*) also illustrates the appearance of a close-mitred hip used with this form of roof covering.

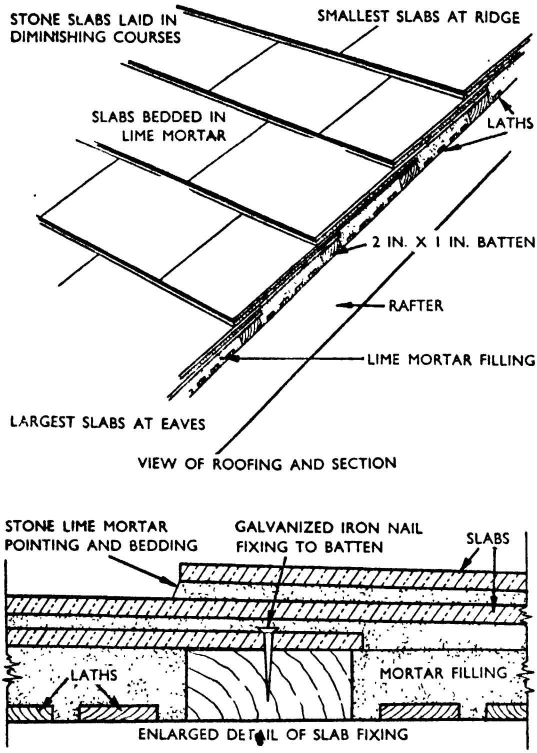


Fig. 5. As a roof-covering stone slates are almost obsolete, and the method of laying is old-fashioned. Note how slabs of stone are completely sealed by bedding. Special attention must be paid to strength of supporting rafters when these are used. (Detail of slab fixing is shown horizontally for purposes of convenience.)

the character of a clay tile, the saving in cost is worthy of consideration where expense is a major problem. Asbestos-cement tiles, which are being marketed in increasing quantities, will be described in common with other asbestos goods in a later section, while wood shingles are briefly surveyed at the end of this section.

Qualities. Clay tiles are sold as firsts, recognised as tiles consistent in size, and free from twists and firecracks; seconds, being tiles properly burnt but with slight twists or other minor defects; and thirds, having fire-cracks and/or bad twists. Tiles having fire-cracks on surfaces exposed after laying should be rejected. Concrete tiles are not classified into grades, the manufacturers' name being used as a guide to their quality.

Types and Sizes (Figs. 6 and 9). Unlike slates, which must rely only on colour and size to give variety, tiles are produced in a number of different types. The most common is the double lap or "plain" tile, suitable for all styles of roofs except where the pitch is below 45 deg., being a rectangular tile standardised at a size of 10 × 6½ in. It is laid, as the name implies, so that each tile overlaps the tile two courses below, thus giving a minimum cover of two tiles to all parts of the roof, and three thicknesses of tile in part.

"Plain" tiles are usually, and preferably, cambered, that is bent in length and sometimes in length and width, and this ensures that the tail has a tight seating while at the same time allowing air space between the tiles, which facilitates drying-out after satura-

tion, and the tiles are supplied with two head nibs, or, in the case of certain concrete tiles, with a continuous nib for hanging to battens.

Other types frequently met with are pantiles, single and double Roman tiles, Italian, Spanish and various patent interlocking tiles. All these varieties are *single-lap* tiles giving head and side cover only, and allowing a single thickness of tile covering to the major part of the roof.

One advantage over "plain" tiling afforded by single-lap tiling is that a lower roof pitch may be used, as joints are fewer, a side lap is provided, and the tilt between the face of the rafters and the tail of the tile is not so great. But even with single-lap tiling a pitch of less than 35 deg. should not be used in conjunction with open battens and in no case should a pitch lower than 30 deg. be adopted.

It is also considered advisable to avoid single-lap tiling on roofs which are cut up with numerous dormers, valleys and gables, as the finish at these points cannot be executed so neatly as with "plain" tiling. Again, on very small roofs their bold lines do not suit the scale. The size of single-lap tiles varies considerably with the types, although in all cases they are much larger than "plain" tiles the length generally approximating to 15 in., the width of Pan and Roman tiles averaging 9 in., while Spanish and Italian tiles have, of course, diminishing widths.

Colours. The colour of clay tiles depends upon the particular earth used and the amount of burning to which they are subjected, the finished product covering a wide range of shades, including light and dark browns, reds and mottles. In choosing a tile the effect of

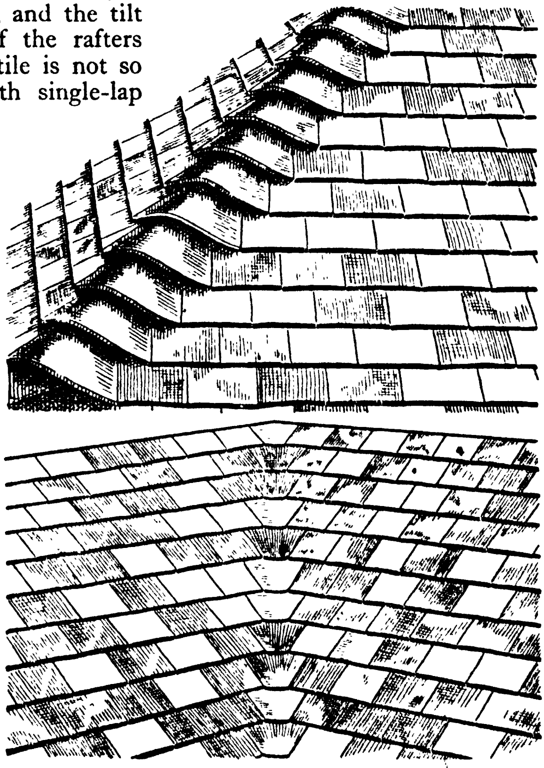


Fig. 6. Finish at hips and valleys to roof-covering of cambered double-lap tiles. (*Top*) Hip covered with bonnet tiles. (*Bottom*) Neat and inexpensive finish given to valleys by the use of purpose made valley tiles.

weathering should always be taken into account, as the colour after exposure for some while will be very different from the sample tile chosen. Concrete tiles are coloured by pigments incorporated in the concrete mix, and are available not only in a range of colours to match clay tiles, but also in shades of green and blue. There appears to be a tendency for these latter to fade. Certain tiles, usually pantiles, can be obtained with a glazed finish of various colours, but the high cost of these has, up to the present, restricted their use to a great extent.

Preparation of Roofs

The preparation of roofs is carried out in exactly the same manner as for slating, with the exception that tiles are never nailed direct to boarding, batten sizes for "plain" tiling are usually $1\frac{1}{2} \times \frac{3}{4}$ in. or 1 in. as against 2×1 in. for slating. An alternative method of preparation for "plain" tiled roofs is to use feather-edged boarding, the boarding being laid overlapping to suit the tile gauge with the feather-edge pointing to the eaves. This provides a close-boarded roof without the necessity of battening but leakage water cannot escape freely. Spanish and Italian tilings require vertical as well as horizontal battening, the size of these vertical battens varying with the tile used.

Nails and Nailing. For double-lap nibbed tiles galvanised nails are satisfactory, as the main weight of the tile is taken up by the nibs. Nailing every course is not considered necessary and it is usual to secure the tiles from alternate courses on steep pitches to every eighth course on very low pitches. On single-lap tiling it is, of course, necessary to nail every tile and advisable to use a tougher and more durable type of nail, such as composition. Zinc and copper nails are not frequently used in tiling work.

Lap and Gauge. The meaning of these terms has already been described under slating, and the advisability of quoting lap and size in preference to gauge and size holds good. The amount of lap required in tiling varies with the type used and the pitch of the roof, but a good general guide is minimum 3 in. for single-lap and minimum $2\frac{1}{2}$ in. for "plain" tiling.

Eaves. All eaves, both to double and single-lap tiling, must be double, and special-sized "plain" tiles can be readily obtained for this purpose. Pan, Spanish and Italian tilings are usually closed at the eaves with tile fragments or coloured cement to tone with the remainder of the roof. The appearance of the eaves can be greatly improved by securing the under-eaves tile to a tilting fillet or, better still, where cost allows, by using sprocket pieces to slow the pitch of the roof as it approaches the gutter.

Verges. In all roof tiling, under-cloaks should be used to verges. These are formed both in "plain" and single-lap tiling, with one or more thicknesses of un-nibbed "plain" tiles bedded on the rake of the gable, and projecting beyond the wall face under to give a good weathering. In "plain" tiling every alternate course should end at the verge with a special "tile-and-a-half tile", to avoid cutting and the use of half tiles. Barge boards are no longer in common use except in

half-timbered work, but where they are employed the roof timbers and battens are carried across the overhang on purlins, or cantilevered brackets. A tilting fillet is sometimes provided, or the barge board fixed to stand proud of the battens, taking the place of an under-cloak.

Ridges (Fig. 4). For single-lap tiling half-round ridge tiles are used in preference to any other, the pockets left under the ridge in Pan and Spanish tiling generally being filled with several small pieces of "plain" tile of diminishing sizes. Half-round ridge tiles are also used more extensively than any other on "plain" tiling, although angular tiles are sometimes preferred.

Hips (Fig. 6). The two methods of finishing hips on single-lap work are with half-round tiles, used extensively on all types, and cone tiles, which are frequently used on better-class work in conjunction with Spanish and Italian tiles. Hips on "plain" tiled roofs can be covered in the following ways: (*a*) with bonnet hip tiles, giving perhaps the most pleasing appearance and almost always employed where hand-made tiles are used; (*b*) with half-round tiles, the cheapest and therefore the most common; (*c*) with close-fitting hip tiles, which are used in considerable numbers with machine-made, principally concrete tiles, and give a very neat finish. The angle of the hip tiles must be related to the roof slope.

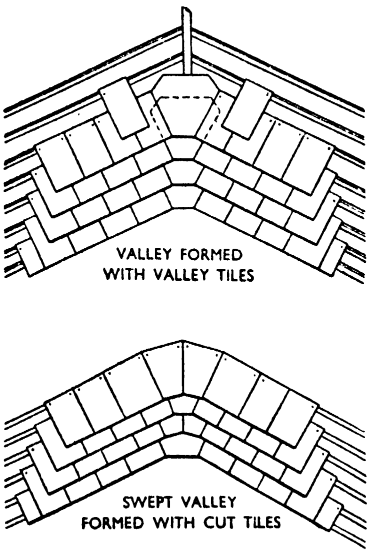


Fig. 7. Finish at valleys on roofs covered with double-lap tiles. (*Top*) Purpose made valley tiles; this is the simplest and least expensive method of finishing at this point. (*Bottom*) Cutting of tiles to form a swept valley.

Valleys (Figs. 6, 7 and 8). To "plain" tiling these do not present any difficulty, as special valley tiles are manufactured for this purpose and provide a cheap and quick method of finishing at this point. Alternative to these are laced valleys, which are formed with the use of valley boards and tile-and-a-half tiles (which can be bought from stock), laid diagonally across the valley board, while the last few tiles in each course are cut splayed and given an upward lift. Swept valleys, the other alternative, are prepared for in the same way as described for slating, that is by boarding across the intersecting rafters to allow for the radius of sweep required and for firring and battening. The tiles are then cut tapered to ensure close jointing, but it must be borne in mind that widening the sweep is lowering the pitch, and consideration must be given to this to avoid slowing the fall too much.

Laced valleys cost more than valley tiles and entail a certain

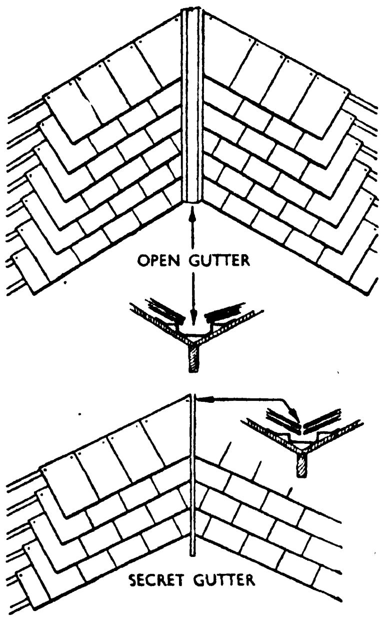


Fig. 8. Alternative finish to valleys on roofs covered with double-lap tiles. (*Top*) An open gutter of flexible metal. (*Bottom*) A secret gutter in which the metal is well concealed by the overhanging of the tiles.

amount of cutting, while swept valleys are a luxury, on account of the additional preparation required, the large amount of cutting and the extra care necessary. Open gutters and close-mitred valleys with soakers or secret gutters under can, of course, be used on "plain" tiled work as described for slating, but in view of the very practical alternatives there does not seem any reason why these should be resorted to unless specified.

For single-lap tiling open gutters are generally adopted, although on certain types half-round tiles placed conversely are used to form the valley and avoid the rather unsightly appearance of exposed metalwork. They are, however, difficult to render effectively watertight. Close mitring of single-lap tiles is not really a practical proposition.

Repairs to Tiled Roofs form a relatively simple task provided that tiles similar to those existing are obtainable. Some of the less common forms of tiling are shown in Fig. 9. In "plain" nibbed tiling where a single tile has fractured this can be speedily replaced merely by levering the tile above, taking out the defective tile and slipping the new one in place with the nibs hooking over the batten. Where the damaged area is large it is simply a matter of removing tiles until a surround of sound tiles is found, making up to original number with new tiles, and starting from the bottom, nailing where required, and finishing to the top course of the affected area as described for a single tile.

The problem is slightly more difficult in regard to single-lap tiling, as the tiles are nailed every course, which theoretically makes it necessary to work from the damaged section right up to the ridge; and taking off and re-setting the ridge capping after the highest course has been re-nailed.

Use of Clips

Clips can, of course, be used to secure the tiles in the top course of the affected area, but they tend to upset the bed of the tiles, and even when pointed up with a plastic compound a weak point is left for the weather to attack. Actually, for normal work where only single tiles are affected these are usually replaced by coating the heads of the replacement tile and the tile below with mortar,

or putty and paint, slipping the tile into position and working to and fro until a good grip has been obtained. It will be found that when the coating material has set the tile will be very firmly held. Tiled roofs which are in a generally bad condition are sometimes rendered watertight by torching, that is, filling up the interstices from the underside with lime mortar and hair incorporated, while for emergency repairs to seriously damaged roofs felt laid over the apertures as described for slating can be used. A more generous margin should be allowed either side on account of the unevenness of tiled surfaces.

Generally asbestos-cement materials enter the field of roofing in the form of slates, tiles, corrugated and angular section sheetings and rain-water pipes and gutters. Being light in weight, durable, impervious to climatic change, rot, vermin and most acids, as well as of low cost, the demand for this material will almost certainly continue to increase rapidly. In relation to slates and tiles, asbestos-cement has the great advantage of extreme lightness, thereby permitting the cutting in size and quantity of roof timbers to a rather considerable extent. Comparing this material with iron, in the form of galvanised corrugated sheets and cast-iron rain-water goods, the

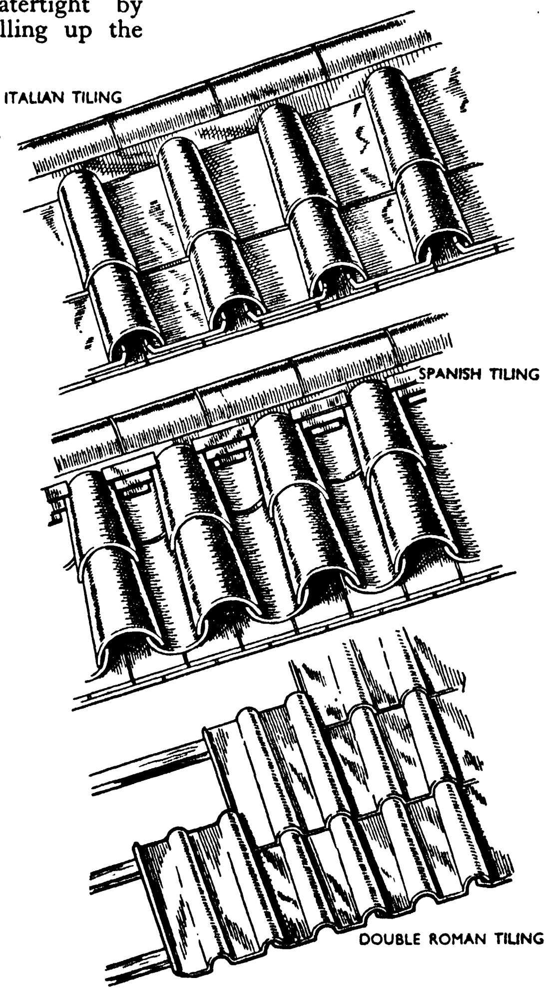
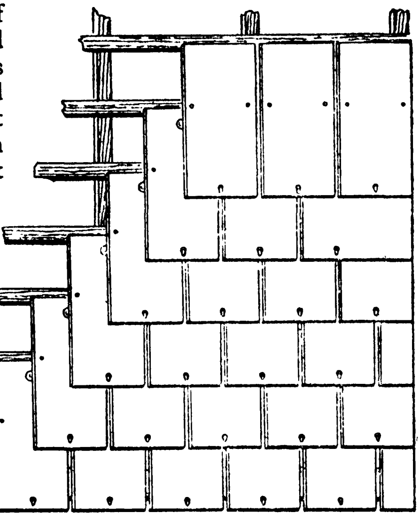
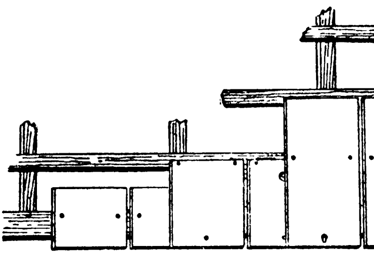


Fig. 9. Less common forms of tiling. The use of these tilings is generally restricted to public and other large buildings, as their cost is prohibitive. Spanish tiling is most frequently employed in this country.

primary advantage is clearly the fact that it is free from attack by rust, with the consequent saving in maintenance costs.

Slates (Fig. 10). Diagonal-shaped slates are the most popular. Supplied at a standard size of $15\frac{3}{4} \times 15\frac{3}{4}$ in. they are secured by means of copper disc rivets and, usually, zinc or galvanised nails, and are generally laid direct on to close boarding, although open battening (with or without felting) can be used. Pitches as low as 25 deg. can be adopted provided that sufficient lap is given. Eaves are finished with a straight edge by halving the lowest course and laying double. Ridges and hips can be finished in any of the ways described for

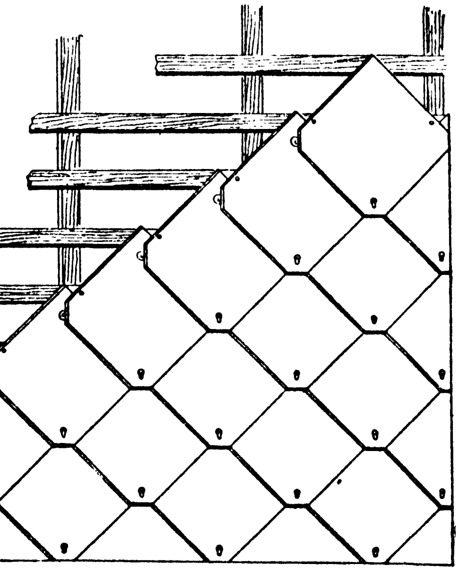
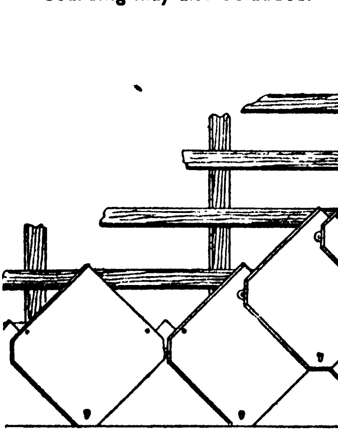



Fig. 10. Asbestos-cement slates. Method of fixing for rectangular and honeycomb-pattern slates. For clarity, fixing to open battens is shown, but felt and/or boarding may also be added.

ordinary slating except close mitring, while valleys are best formed with open gutters or close mitring with soakers under.

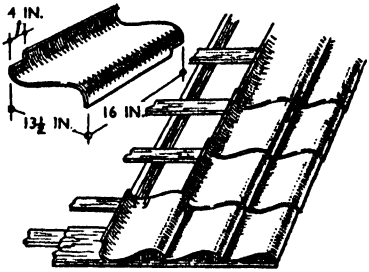
These slates are available in a limited range of colours, including natural, red and russet, brindled and blue. Asbestos slates are also supplied similar to natural slates in varying sizes up to 24 × 12 in., the preparation for and method of laying being identical, except that, as with diagonal slates, copper disc rivets are included for position holding. Colours are available in the same range as for diagonal slates.

Tiles (Fig. 11). Asbestos-cement tiles are manufactured in the form of pantiles available in sizes, referred to as large and small, approximating to 15 × 13 in. and 15 × 9 in. respectively. Roofs are prepared in the same way as for normal single-lap tiling, although, as for asbestos-cement slates, the size and quantity of timbers can be reduced considerably in comparison with those required for clay or concrete tiles.

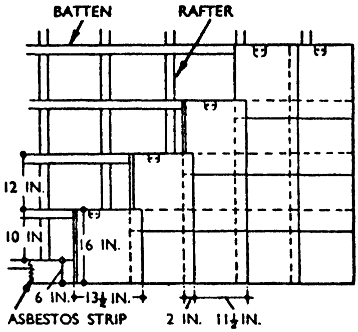
Method of Fixing

Each tile must be secured with two nails, zinc or galvanised being sufficiently strong. The tiles at eaves are bedded on to a plain asbestos strip covered with wire netting or expanded metal, and stop end eaves tiles are supplied in the larger size to avoid the gap left by the roll, while in the small pantile this should be pointed up in coloured cement. Pantiles with a double roll are available to give a finish to the left-hand verges, but a consistent overhang either side is essential. Under-cloaks are advisable.

Half-round asbestos-cement tiles, strengthened with a firm concrete backing, are used for ridges and hips, and special under-ridge pieces are procurable to cover the voids left by the pans, or, alternatively, these can be filled with tile pieces and cement. Hip irons should be provided. Valleys are best turned with open gutters, the tiles adjoining the valleys being bedded on a plain strip and wire or expanded metal, as for eaves. Special large tiles are supplied for this position as well as next hips to ensure secure fixing. The principal colour for these pantiles is a russet to tone with the clay tile, but they are also obtainable in some shades of green.



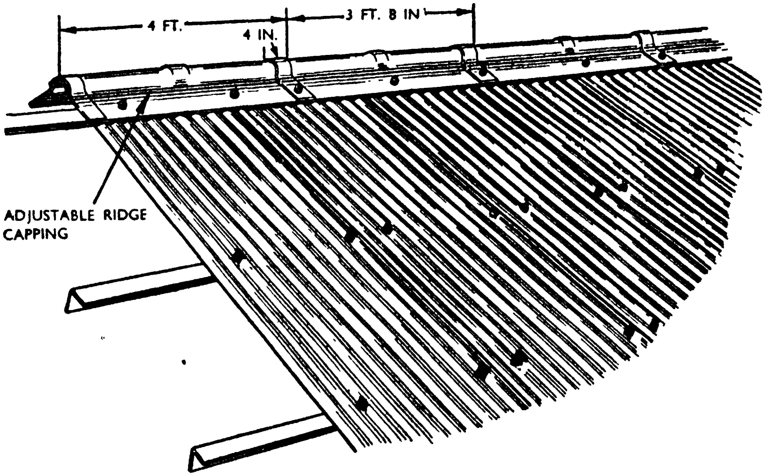
EAVES TILES WITH STOPPED END



SETTING OUT OF BATTENS AND TILES

Fig. 11. Asbestos-cement pan tiles. These form a very popular low-priced roof-covering. (*Bottom*) Details of laying, position of fixings and gauge. Felting and boarding can be used in conjunction with the open battens.

Asbestos-cement sheets (Figs. 12 and 13) are used extensively on industrial buildings, garages and outbuildings, and are marketed in several types, such as, in order of cost, standard corrugated, large corrugated, angular section and, for positions where a flat soffit is



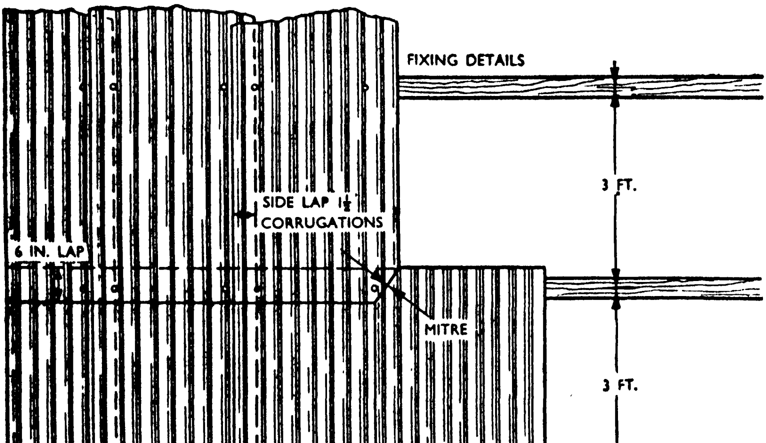


Fig. 12. Asbestos-cement corrugated sheetings. Details of minimum end and side lap for standard-type sheets and positions of fixings. (*Top*) Apex finished with an adjustable ridge capping piece. Alternatively, close fitting or ventilating ridge pieces may be used. The sheets are obtainable in sizes to suit most purposes.

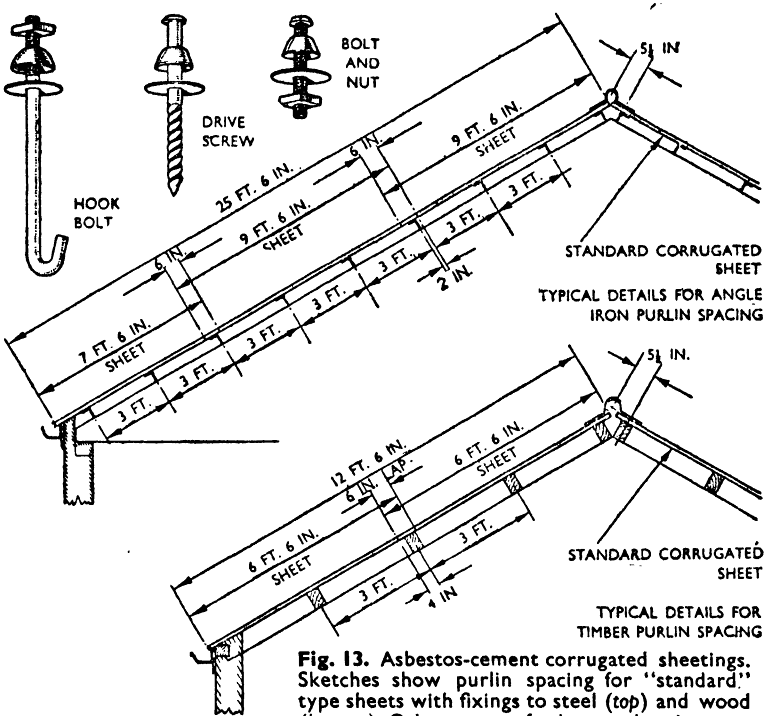


Fig. 13. Asbestos-cement corrugated sheetings. Sketches show purlin spacing for "standard" type sheets with fixings to steel (*top*) and wood (*bottom*). Other types of asbestos sheetings can be used in cases where a wider spacing of the purlins is necessary or desired.

required, combined angular section sheets. They have advantages over and above those enumerated in the first paragraph in being very easy to handle and fix and allowing for wide purlin spacing (up to 3 ft. for standard and 4 ft. 6 in. for large corrugated and angular section sheets). Sheets are sold in lengths from 3 to 4 ft., rising in increases of 6 in. up to 10 ft. Widths range between 2 ft. 6 in. and 3 ft. 9 in., according to the type and make of the sheets.

Fixing is carried out by means of drive screws for timber purlins and hooked or flat bend hook bolts for steel purlins, of galvanised iron, and fitted with lead cupped and asbestos washers supplied by the manufacturers. End laps are consistent at 6 in., side laps are dependent on the type of sheet used.

Finishing Accessories

Accessories for finishing at ridges, hips, eaves and verges in the forms of close-fitting adjustable pieces for ridges and hips (or ventilating, if required, for ridges), finials, filler pieces for eaves, barge boards for verges are all available as stock items, as well as apron pieces, soakers, lay lights and ventilating dormers for use with these sheetings. All the above sheetings are stocked in natural, red or russet colours.

Rain-Water Goods (Fig. 14). Eaves and valley gutters, down pipes, swannecks, shoes, branches and elbows are all available in similar sizes to those ruling for cast-iron fittings, but metal pipe ears, holderbats, clips or brackets must be used for fixings. Jointing material for these fittings can be supplied by the makers.

It should be mentioned before leaving the subject of asbestos cement roofings that the material is also marketed in the form of hollow construction or reinforced troughed sheets for use as flat roof coverings; and where very heavy bearing loads are not essential these are well worthy of serious consideration.

Flat Roofs

There has been a great deal of controversy regarding the suitability of flat roofs for the British climate, but it seems fairly safe to contend that flats are basically less sound than pitched roofs on the counts both of weather resistance and insulating qualities; and any saving in cost which may be claimed on materials is usually offset by the more complicated base construction necessary if these are to compare favourably with other forms of roof coverings. It may be added that while a pitched roof can be constructed with very inferior materials and still give satisfaction for a number of years, to attempt to apply this to flat roofs would be fatal as only by the use of the best materials available and careful workmanship can the inherent disadvantages be overcome.

The five most common materials met with for the roofing of flats are copper, lead, zinc, asphalt and roofing felt, the characteristics of these various materials being as follows: (1) Copper sheeting, the most durable, will outlast almost any material upon which it is imposed and has unique weathering qualities, colouring to a pleasing green upon oxidation. It is also comparatively light and easily worked. The primary reason for the infrequent use of this material is its excessive cost while the necessary roll and welt jointing is a disadvantage where the flat is required to take traffic, although this can be overcome in part by the use of duckboards. The method of buying copper sheets is by quoting the standard gauge required, 24-gauge metal being accepted as the best average weight for general purposes.

(2) Lead, by far the most widely used of metal roof coverings, has a very long life, is impervious to practically everything, can be more easily worked than any other material and is much cheaper than copper. Against these points must be set the disadvantages of extreme weight, the necessity of forming drips in the fall and a less neat finish. Even more so than copper, lead is not ideal for flats taking traffic, on account of the drips and rolls.

Lead for flat roof work can be either cast or milled, but the use of cast sheet, although the more durable of the two, appears to be rapidly diminishing. The method of buying this material is by weight per square foot, the normal weight of metal used for any but very small flats approximating to 7 lb. per ft. super.

(3) Zinc, widely used for repair work and buildings of a semi-permanent nature, is best avoided on really permanent structures, as the average life of this material

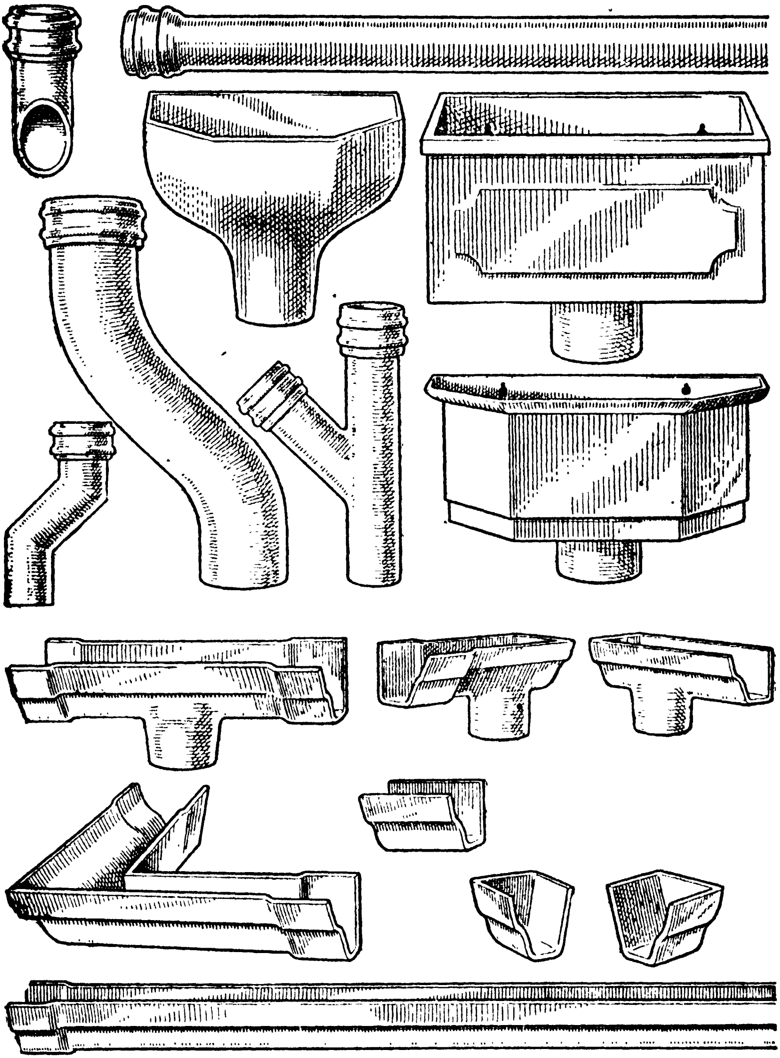


Fig. 14. Asbestos-cement rain water goods. Illustration shows pipe lengths, shoes for discharging over open gullies, heads of various patterns, swannecks, bends and junctions, gutter with outlet, right- and left-hand stop ends with and without outlet return and straight gutter lengths.

is rated at only twenty-five years; and in some districts, where atmospheric conditions are unfavourable, is considerably less than this figure. Zinc is specified by gauge in the same way as copper, 16-gauge metal being a good weight to remember for general purposes.

(4) Asphalt can lay claim to

one very great advantage over metal roof coverings in respect of being jointless, thus avoiding the weaknesses inherent in welts, seams, drips and rolls and giving an unobstructed, smooth, dustless finish which is eminently suitable for flats where frequent traffic is to be anticipated. On the debit side it cannot be denied that asphalt is less durable than metal coverings of equal or greater cost and has a tendency to crack, although this is usually through insufficient care being taken in preparing the base or skimping in the thickness of the material.

One other factor which restricts the use of asphalt is the rather cumbersome plant necessary for heating the material to a suitable flux for laying, which makes it an uneconomical proposition on very small flats.

(5) Roofing felt is quite useful for covering sheds and other buildings of a temporary nature, being cheap, and, if properly laid, giving a weatherproof job which will last a number of years. The felt can either be tar (fluxed pitch) or bituminous, the latter being available in a self-finished quality which is preferable for this class of work, as sand or slate surfaced felts have a tendency to retard the flow of water on such slight falls. Felts are sold in rolls of varying weight per square yard.

Preparation of Roofs. Flat roofs can be constructed of timber joists covered with close-jointed, preferably tongued and grooved, boarding, the joists either being laid on the rake or firred to provide the necessary falls. This construction is suitable for all types of coverings, drips being formed, where required, by firring, except to very large flats, where differing sized joists or stepped soffits may be adopted, the drips coinciding with the position of the bearers. Concrete roofs are used almost exclusively in conjunction with jointless roof coverings. They may be precast, in situ, slabs of hollow block, and where on a horizontal plane the falls are provided by screeding, preferably with a foamed slag or pumice concrete, the minimum thickness of which is best kept at 1½ in. Concrete roofs have the advantages of greater durability and less movement, but are much more expensive on account of the increased weight placed on the under structure. Again, they have a tendency to "sweat" unless very carefully insulated at additional cost.

Laying (Fig. 15). The first essential in laying all the above roof coverings is to make sure that the base is absolutely smooth, and for this reason nails should be of the flat-headed type and well punched in.

Copper Laying

Copper, which is best laid to a minimum fall of 1 in. in 4 ft., usually has a base covering of building paper, felt or, where desired, insulating board secured to the boardings with nails of the same material. Joints running parallel to the fall are formed with tapered wood rolls, approximately of 2 × 2 in., screw fixed to the boarding, the copper sheet on one side being turned up against the roll and bent back upon itself, while the other sheet is carried over the roll, turned down and under the groove provided by the first sheet and forming a welted joint. The joints are secured in position by the provision of copper clips

placed at the top and bottom of each sheet.

Joints running across the flow are executed in a similar manner, except that the wood rolls are omitted; the turn-up should not exceed ¾ in. and the joint is dressed flat in the direction of the flow. If, for any reason, a slower fall than the minimum suggested be used, the welted cross joints must be omitted and drips substituted. Where the sheeting abuts upstands, such as parapets and chimneys, the metal is turned up a minimum of 4 in. and a cover flashing fixed, the joints in the skirting at the roll being finished with saddle pieces. Rolls at eaves or gutters are stopped with roll ends welded on.

Lead (Fig. 15) is generally laid direct on to smooth boarding and jointing is reasonably simple. Vertical (*i.e.*, with the flow) joints are provided for by the use of wood rolls, approximating to 2 in. diameter, secured to the boarding with the lead sheet on one side turned over the roll to slightly beyond the centre and copper nailed, the other side being turned completely over the roll and extending a minimum of 1½ in. on the flat without being secured. This allows for expansion and contraction. Horizontal joints are, owing to the bulkiness of this material, overcome by the adoption of drips, which are small steps formed in the fall by firring, the minimum practical depth of these being 2½ in.

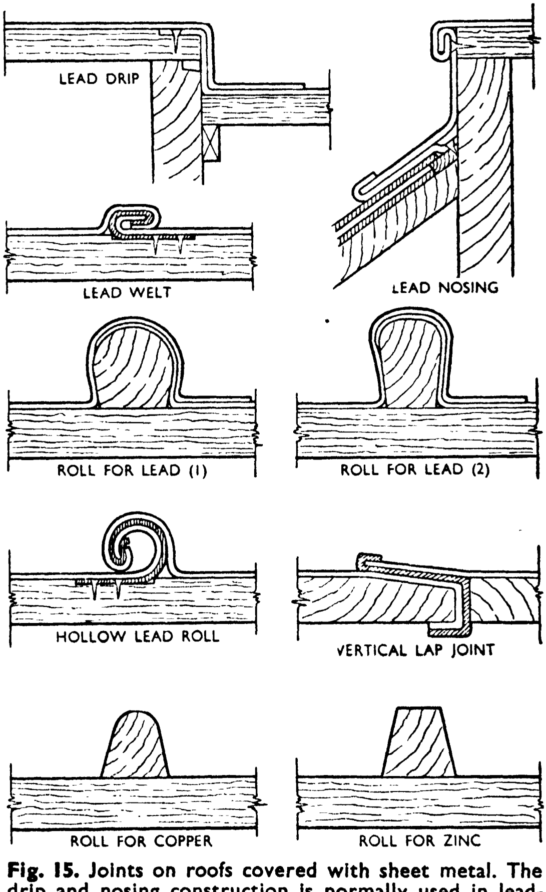


Fig. 15. Joints on roofs covered with sheet metal. The drip and nosing construction is normally used in leadwork for joints running across the flow, while wood rolls are almost standard for joints running with the flow. Welts and hollow rolls are seldom used for lead. Note the varying shapes of rolls for lead, copper and zinc. (The lap joint for vertical surfaces is shown horizontally for purposes of convenience.)

The lower sheet at this point is turned up against and over the drip and nailed, while the upper sheet is dressed down over the drip, extended on to the flat for a minimum of 1½ in. and left loose. Seams and welts can be, but seldom are, used in lead coverings, and, as welted horizontal joints are not here considered, the minimum fall for lead flats can be as slight as 1 in. in 7 ft. As for copper, where this covering abuts upstands a minimum turn-up of 4 in. should be provided together with a cover flashing.

Zinc (Fig. 15) is also usually laid direct on to smooth boardings, joints running parallel to the flow being formed with tapered wood rolls similar to those described for copper. The finish at this point is carried out by turning the zinc up against the roll both sides, stopping short of the upper face and securing with metal clips, which are fitted round the rolls and bent over the free edges of the sheets. A separate zinc capping piece is then placed over the roll to overlap the sheets either side, the capping being held in position by soldering on thin strips to slip under the clips in common with the edges of the sheet turn-ups.

Provision of Drips

Drips are provided as in leadwork for forming the joints across the flow, the lower sheet being turned up against the drip and bent outwards, while the upper sheet is projected over the drip and bent under the angle formed by the lower sheet. Next to vertical surfaces the zinc is turned up 4 in. and a cover flashing fixed. The fall for zinc flats can be the same as that already given for lead.

Asphalt. For good results this material should always be laid in two operations to a minimum thickness of 1 in., although a finished thickness of ¾ in. is sometimes specified and one coat work occasionally used on cheap work. Where laid on to boarding, asphalt should always have an underlay of stout building paper, or, better still, roofing felt, to take up any movement in the base. The addition of a layer of expanded metal laid on the paper or felt is also sometimes provided to act as a reinforcing factor.

Formation of Skirtings

On concrete roofs the asphalt can be laid direct on to the screeding, but here again a loose layer of some material to avoid cohesion between the base and the covering is a distinct advantage. Where abutting vertical surfaces the asphalt is turned up against the wall face in a continuous operation to form a skirting normally not less than 6 in. high, which is finished by tucking into a chase or brickwork joint. Fillets should be provided at the base of skirtings to avoid sharp angles which have a tendency to crack; while at the eaves the best practice is to provide a welted metal apron. The asphalt is stopped about ¾ in. back from the eaves fascia, and the apron dressed down into the gutter. Falls in asphalt roofing should not be less than 1 in. in 4 ft.

Roofing Felt. Felt on flat roofs should not as a general principle be laid in less than two layers, although on concrete flats a single layer can prove satisfactory for a short time. On the other hand, more than two layers of felt are seldom resorted to for this class of

work, as the rising cost brings the alternatives of metal or asphalt roof coverings into competition with it.

The method of laying on boardings is to nail the lower sheet with galvanised clout nails along the centre of the laps and vertically or diagonally across the sheets, as may be considered necessary, and continuously seal the upper sheet to the lower with bitumen or coal-tar pitch, as determined by the type of felt used.

On concrete flats the lower sheet is either continuously sealed to the base or, alternatively, spot fixed at 2 ft. or 2 ft. 6 in. centres, the latter method finding favour where the area of the flat is large. The upper sheet is then laid as for wood flats. Next to upstands the felt is turned up to form a skirting and turned into a chase or

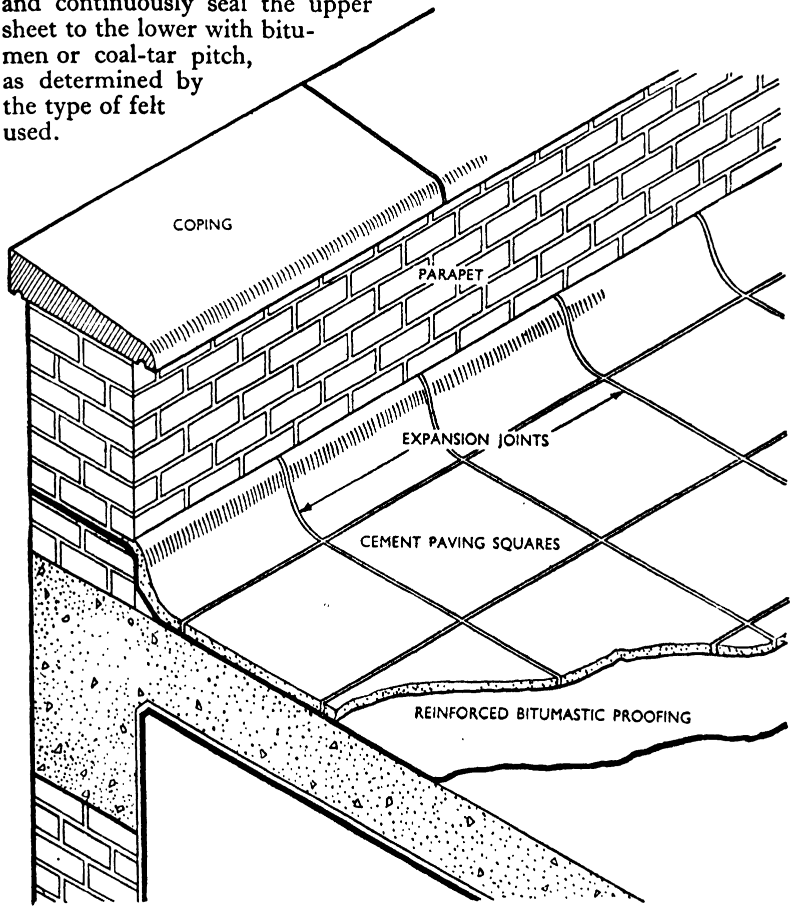


Fig. 16. Built-up flat roofings. Paropa type patent roofing, which comprises a reinforced bitumastic waterproofing of felt and hessian covered with cement paving-squares. This is suitable for laying on concrete or wood flats, and gives a very pleasing finish where it is desired to use the roof as a garden, sun terrace or playground. Details of suggested method of finishing are given in Fig. 17.

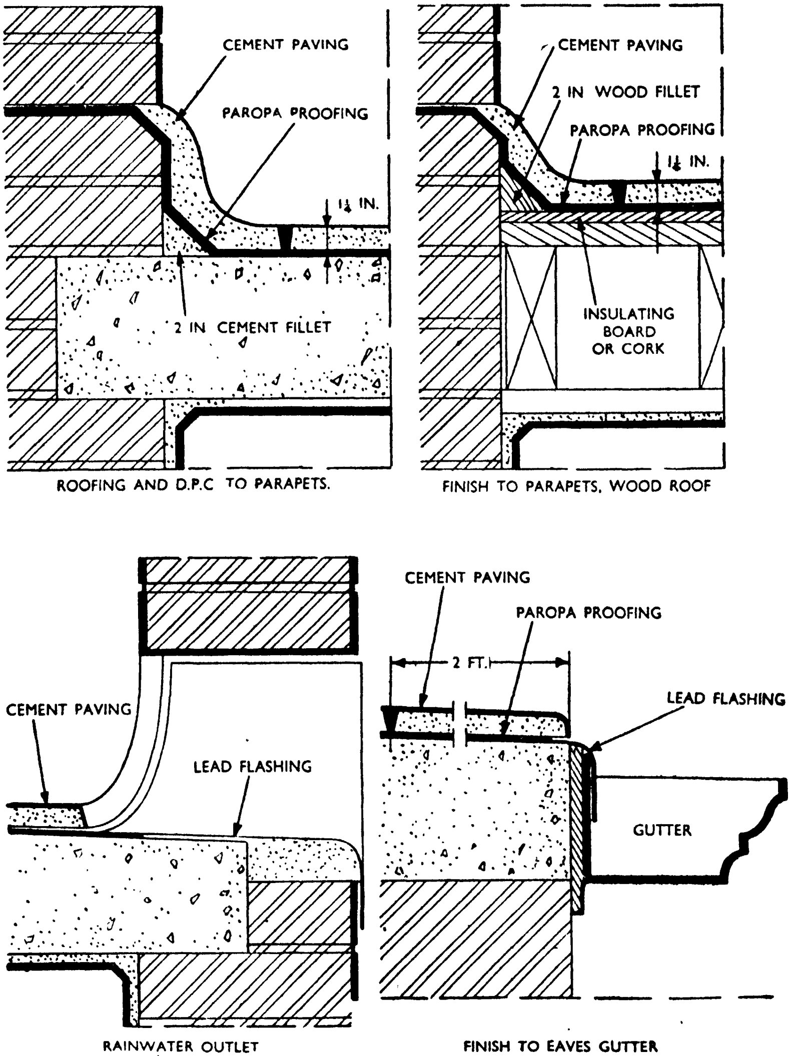


Fig. 17. Paropa patent roofing giving details of the suggested method of finishing the covering materials at parapets, outlets and eaves.

brickwork joint, and generally protected with a metal cover flashing. A splayed fillet should be provided at the bases of skirtings where tar felts are employed. All felts should be laid with minimum 2 in. laps, and in no case should the slope of the roof be less than 1 in. in 5 ft.

Composite Roofs (Figs. 16, 17 and 18). The types of roof coverings previously discussed have

been dealt with principally from the point of view of protection against weather, but the recognition, in recent years, of the value of flat roofs as a means of providing garden space in closely built up areas has created a demand for coverings which combine known water-resisting qualities with an attractive finish, such as paved or tiled surfaces.

Combined coverings of this type must generally be classified as "specialised" construction, and new methods are being constantly worked out. The cost is naturally more than most coverings intended purely for weatherproofing, although it should be mentioned that asphalt is a finish which in itself satisfies the conditions usually demanded for roof gardens. Where desired, it can be supplied in colours, and it may also be patterned by laying the finishing coat in squares or strips.

The problem of rendering slated and tiled roofs watertight next to abutments and upstands is a serious one, and is responsible, perhaps to a greater degree than any other factor, for heavy expenditure on periodical maintenance unless care is taken in the first instance. In view of this, the practice of sealing the joints at these points merely with a sand and cement fillet, so often seen on cheap work, must be strictly avoided. The method of overcoming this difficulty most generally accepted as good building practice is by the employment

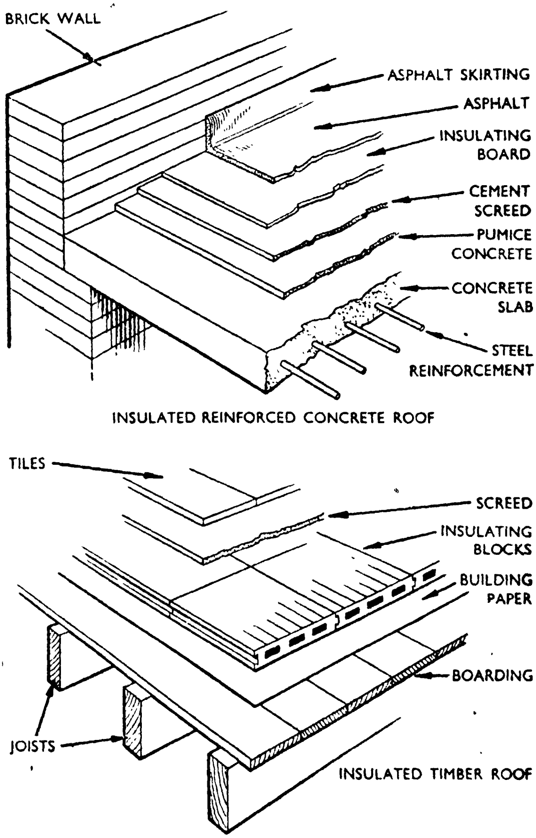


Fig. 18. Insulated timber and concrete flat roofs. Possible form of construction where the rooms below are required to have a reasonably stable temperature. There are a number of satisfactory ways of providing for this, and the method adopted depends to a great extent on the amount of insulation that is required.

of a flexible metal such as copper, lead or zinc, in the form of aprons, soakers and flashings; but as there are several different ways of performing the work, it will clarify the position first to briefly explain the meaning of the technical terms involved and then give details of their application:

Aprons (Fig. 19) are metal strips used where the slope of the roof strikes an upstand on a horizontal plane. This strip (which should not be less than 12 in. wide and a length equal to the overall dimension of the upstand plus a minimum margin return of 6 in. either side) is bent lengthwise to suit the angle between the vertical face and the roof slope to provide about a 4 in. turn-up, the remainder being dressed down over the roof surface.

Soakers (Fig. 19) are often used where the roof slope rakes across an abutment or upstand, and also under hips and valleys where a close-mitred finish is employed. Those used next to wallings are generally 7 in. wide by a length equal, in the case of slating and double-lap tiling, to the slate or tile minus the amount of face exposed, plus an additional $\frac{3}{4}$ in. on the bed to form a fixing clip. Soakers for single-lap tiling are similar, but provision for head clipping is omitted, the length of these being identical to the gauge.

For mitred hips and valleys, soakers are cut parallel and returned at right-angles to the roof slope, each side thus forming unequal diagonal pieces of a size sufficient to allow the base of one to lap the apex of the other. The determining factor is the size of slate or tile used.

Flashings (Fig. 19) are of two types: (1) cover flashings which are metal strips used to cover and lap over the free edges of turn-ups for protection and to allow for expansion and contraction, the width of these strips varying between 4 in. and 6 in., and (2) apron flashings, which are the same as aprons but have additional width in the turn-up to allow for finishing at the free edge by turning into a chase or brickwork joint. Their purpose is to replace aprons and cover flashings on the horizontal plane and soakers and cover flashings on the raking plane.

Fixing Terms

Flashings are also classified by the fixing employed, such as raking, which merely infers that the flashing is fixed on the rake, and stepped where triangular pieces are cut from the metal to allow the free edge to be turned into the rising brickwork joints in the form of steps to suit the raking plane.

These fixing terms are coupled to the type to give references such as "stepped (or raking) cover flashings" or "stepped (or raking) apron flashings". "Separate stepped cover flashings" are occasionally used. They are triangular metal pieces fixed in the same way as ordinary stepped flashings and each one overlapping the one below.

Back gutters (Fig. 19) should have a clear bed of at least 12 in. plus sufficient to carry the back edge well under the roof slope, and for a good turn-up. The width of the gutter must allow for a margin and return of not less than 6 in. either side of the upstand, and allowance should be made for a back fall from the upstand.

Having given the meaning of the terms used, a description of

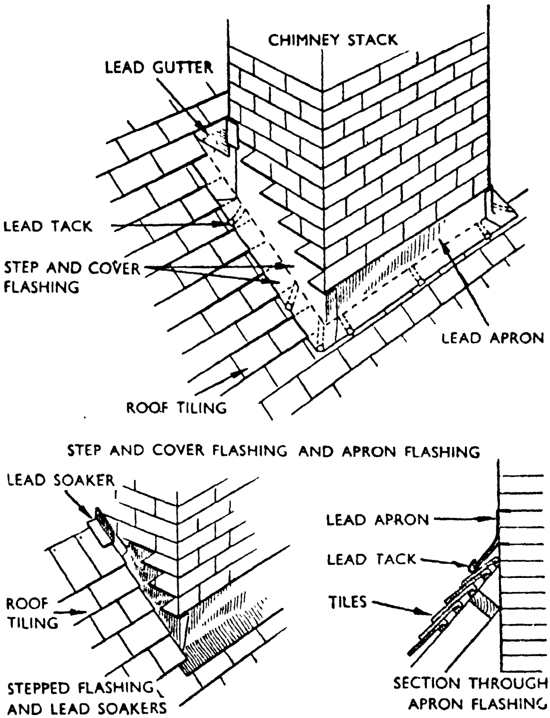


Fig. 19. Method of preventing water penetration at upstands projecting through roofs. (*Top*) Combined apron flashing which is quite frequently employed; but water may enter below the side apron owing to the irregularities of the roof surface. (*Bottom*) Method of having soakers with an independent cover flashing.

their application can be made clearer by taking a single case in the form of a chimney-stack projection standing clear of ridges, hips, eaves, valleys or gables, and describing, in order of preference, the various ways in which the work can be carried out.

Taking the lower face first, as work is always commenced from this point, there are the following alternative methods: (1) An apron and cover flashing, the apron being held in position with metal clips batten-nailed and turned over the tail of the apron, while the tuck in of the cover flashing is secured with metal wedges and pointed with cement mortar.

(2) An apron flashing, fixings being the same as before.

(3) An apron as before, with a course of "plain" unnibbed tiles bedded on the splay against the vertical surface with tightly butted joints to take the place of the cover flashing.

(4) An apron with a reduced turn-up, this being protected with a cement and sand fillet in lieu of a cover flashing.

The practice of leaving the tail of the apron piece clear and extending the slating or tiling across in narrow lengths has the advantage of concealing exposed metal work, but is not recommended, as the necessity of nailing through the apron destroys its function to a large extent.

The next points to be considered are the sides of the upstand on a raking plane: (1) Soakers, and stepped, or raking, cover flashings, the soakers being placed between the first and second thicknesses of the roof covering in the case of slated and double-lap tiled work (the top of the soaker clipped over the head of the slate or tile) and nailed between the boarding

and tile for single-lap tiled work. The cover flashing is secured with metal wedges and mortar pointing as before, and the bottom soakers must be dressed over the apron margin, while the side flashing is dressed over the one below.

(2) Apron flashings as described previously, the turn-up being either tucked into a chase on the rake or stepped cut and tucked into the rising brick courses, while the remaining width is dressed over the surface of the roof covering.

(3) Soakers as before, but the cover flashing being replaced by a tile course as described under (3) for aprons.

(4) Soakers in combination with a cement fillet as described under (4) for aprons.

Finally, for the back face of the stack the only really satisfactory method is: (1) A back gutter and cover flashing, the gutter being laid on boarding framed up between the vertical surface and the rafters to fall towards and across the stack. The back edge of the metal is carried up under the roof covering, turned over a tilting fillet and nail fixed; the margin on either side of the upstand is dressed over the top soakers (or apron flashing), and the cover flashing secured as before and lapped over the side cover flashing. Where this has been replaced by a tile course or cement fillet, the cover flashing is returned behind these.

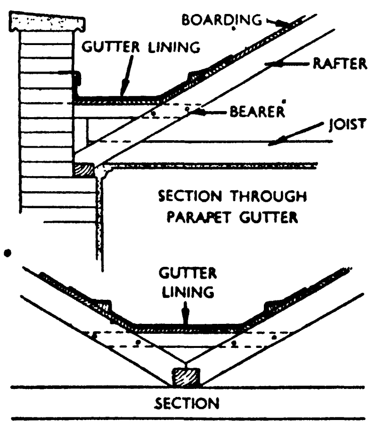


Fig. 20. Valley and parapet gutters to pitched roofs. Gutters are flexible metal or asphalt laid on boarding with supporting bearers under. The "carry up" of the material on the sides must be sufficient to allow storm water to get away without backing up.

The above instructions can be applied to any position where the roof slope is interrupted, the only differences which may arise being upstands formed of timber framing with vertical metal coverings, where cover flashings are omitted and the vertical covering is extended over the soaker, apron or gutter to serve this purpose; and also with skylights or dormers having sill pieces where the turn-ups should be dressed into a groove provided on the underside of the sill piece and nail fixed.

Parapet and Valley Gutters (Fig. 20), where carried out in flexible metals or asphalt can be treated in the same way as small flat roofs; as with the exception that falls should be a great deal quicker and joints with the flow are not employed, the principles already discussed apply. The fact that these gutters are laid to fall parallel with the eaves determines that they must be tapering in plan, and it is therefore advisable to avoid lengths longer than absolutely essential.

Outlets to parapet gutters or valley gutters stopped by a parapet are provided by means of cesspools carried through the parapet or sunk into the roof thickness, a

cesspool being a timber-framed, metal-lined box with joints and mitres soldered or welded, the size of which must be sufficiently large to allow storm water to get away without backing up.

Corrugated Steel Sheetings. Usually referred to as corrugated iron, mild steel sheets, corrugated to give greater strength and galvanised or coated to give protection against rust, are still extensively used for covering temporary and factory buildings, although their market has diminished considerably since the advent of asbestos sheetings. The commonest type of sheet has 3-in. corrugations, a width of 2 ft. 6 in., giving 2 ft. 3 in. clear cover per sheet when laid with 3 in. side laps, and varying in length from 3 ft. in rises of 6 in. up to 10 ft. End laps should not be less than 6 in., and greater where the pitch of the roof is very low.

Fixing Steel Sheetings

Fixing is carried out by hook bolts, to steel purlins, or drive screws to timber purlins, the spacing of these purlins being about 4 ft. The bolts or screws are driven through the head of the corrugations and weathered with a shaped washer and, if so desired, an additional felt washer. This operation must avoid disturbing the galvanised or coated surface. A gauge number should be quoted when ordering, these varying between 16 and 28, a handy reference for small works being 26-gauge metal.

Cast-Iron Rain-Water Pipes. The only kind of iron pipe in everyday use is the round pipe cast complete with sockets and ears, where required, the pipe sizes ranging from 2 to 4 in. diameter, in half inches, and weights from 19 to 34 lb. per 6 ft. length for these sizes, the most general type used being the 3 in. pipe. Joints are sealed with red lead, and fixing is carried out with pipe spikes, projecting ears or distance pieces being used to allow the pipe to stand clear of the wall.

An alternative and cheaper method of fixing is with holdfasts. Special pipes are produced to meet all contingencies in the way of branches, bends and swannecks. A large selection of ornamental rain-water heads is available.

Cast-Iron Eaves and Valley Box Gutters. Eaves gutters can be half round, O.G. or moulded, but except where matching up with existing gutters, the half-round type is nearly always used, sizes being between 3 in. and 6 in., of which the 4 in. gutter is seen most frequently. Jointing is the same as for down pipes, while for fixing, wrought-iron gutter brackets are used either for screwing to a fascia or carried underneath the roof covering, and screwed to the surface of the rafter or sprocket. Cast-iron box and valley gutters are made in stock sizes and shapes to suit practically every case which may arise, but are not used to the same extent as pressed steel or asbestos, principally on account of their weight. Thickness of metal is the normal reference, $\frac{3}{16}$ in. metal representing about the minimum standard.

Snow Boards. Snow, or duck, boards are used to good effect in wide valley gutters, serving the dual purpose of ensuring that laying snow does not choke the gutter, and avoiding damage to the metal when walked along, and for the second reason are also

often used on flat roofs. Their construction generally consists of $2 \times \frac{3}{4}$ in. slats placed 1 in. apart on similar-sized battens fixed running with the flow, and should be made sectional for easy lifting.

Snow Guards are seldom seen today, as they are not really necessary for normal roof pitches in this country. On extensive and steeply pitched slopes, however, they are an advantage, if not all along the eaves at least at the bottom of the valleys, where the greatest mass collects. They should comprise dwarf railings between 12 and 15 in. high, fixed to the rafters with wrought-iron brackets.

Painting. The only materials discussed where consideration need be given to painting are ironwork and, if required, asbestos cement, although it should be pointed out that painting the latter serves a purely decorative purpose, as the material in its natural state is far more impervious than any coating would be. In regard to ironwork there seems to be general agreement in the trade that paints of a bituminous nature give satisfaction, while for asbestos cement the essential thing to remember is that a special primer to kill the alkali content is very necessary; after which any good-class paint is suitable, but it may be mentioned that bituminous paints are not liable to burning out when used on this material.

Water Penetration

The greatest evil that has to be contended with in respect of building is, without doubt, water penetration, as the damage caused by this is out of all relation to the initial cost of prevention. However, until people can be persuaded that saving pence in this direction will mean the outlay of pounds at a later date and also that the policy of "out of sight, out of mind" applied to the maintenance of buildings is asking for trouble, the repair of gutters and down pipes will remain a steady source of income for property repairers. Methods of repair are numerous and conflicting, but the following notes should prove helpful:

Cast-Iron Down Pipes; Eaves; Box and Valley Gutters. The three most common troubles are, leaking joints, clean breaks and fractures. Joints can usually be rendered watertight by removing, thoroughly cleaning and rebedding as for new pipes. Where a complete break occurs in a pipe or gutter, obviously this must be replaced immediately with a new length.

Repair of Fractures

Fractured lengths should be replaced wherever possible, but as a temporary measure a repair can be effected by thoroughly cleaning the fracture, heating with a blow-lamp, to cause expansion, and immediately filling with a bitumastic compound. Gold size putty is another material sometimes used for this purpose. A repair of this nature will not of course stand any great water pressure.

Lead Box and Valley Gutters. A difficulty often encountered when repairing lead gutters is finding the leak, as it is surprising how much water can enter through a pinhole and, at the same time, the visible penetration on the under side does not necessarily indicate the point of entry. Generally, however, the cause of lead becoming perforated is to be found in the faulty nailing of the under boarding, either by the

nail-heads having been left projecting or the wrong metal being used, for nailing. When the perforation has been located the usual method of repair is as follows: Thoroughly clean the surface of the lead round the perforation with a shaving tool, form a small ring of plumbago or vegetable black, dress the surface inside the ring with tallow. With the aid of a soldering iron drop sufficient solder into the ring to give ample coverage, and immediately spread with a wiping cloth. This will avoid any obstruction being caused by the solder dot, and the plumbago will prevent the metal spreading beyond the affected area.

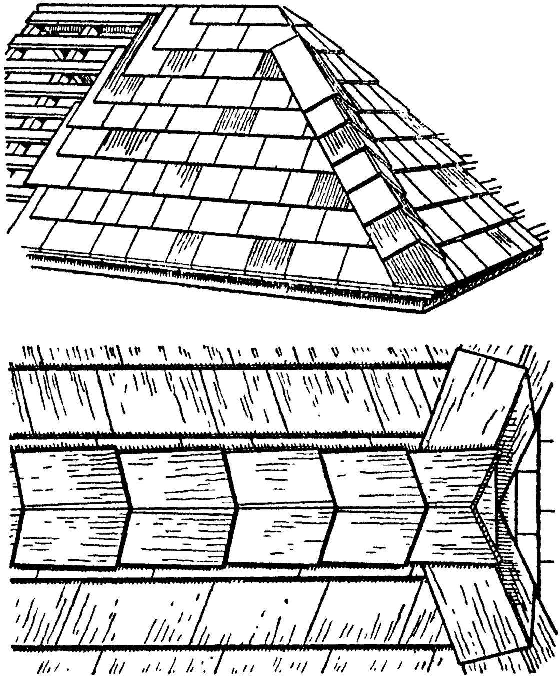


Fig. 21. Simple method employed in covering ridges and hips on wood shingle roofs without change of material. Note the double course of shingles at eaves and ridges. The shingles are nailed direct to the laths.

Zinc Gutters are generally treated in the same way as lead, except that spirits of salts should be used for cleaning instead of a shaving tool. Before use the spirits of salts must be "killed" by placing a piece of lead in the receptacle containing the acid.

Asphalted Gutters. The repair most frequently necessary to these is the resealing of cracks caused by sudden climatic change and/or movements in the base structure. Filling is not very satisfactory, and a better method is carefully to heat the asphalt with a blow-lamp and iron out the affected area. All gutters and pipings should be periodically cleaned and flushed out and corrosive metal surfaces treated with rust-defying paint.

Wood Shingles. Roofs covered with wood shingles are common in America and Sweden and are gaining popularity in this country. In shape and fixing they may be said to be wood slates. The usual size is 16 in. long, of random widths and tapering in thickness from $\frac{5}{16}$ in. at the bottom to $\frac{1}{16}$ in. at the top; the margin should not exceed 5 in. They may be cleft, though they are now usually sawn, and are usually of western red cedar or oak. Fig. 21 shows the method of laying the shingles.

CHAPTER 3

FLOOR CONSTRUCTION AND REPAIR

TYPES OF FLOORS. BEAM-TYPE FLOORS. WORN BOARDS. SHRINKAGE OF BOARDS. DRY ROT AND OTHER DISEASES. SOLID FLOORS. WOOD-BLOCK FLOORING. STRIP FLOORING. PARQUET. PLYWOOD. LINOLEUM. COMPOSITION FLOORING. TERRAZZO. GRANOLITHIC AND CEMENT FLOORING. RUBBER. CORK. TILES. ASPHALT. DOUBLE FLOORS. SILENT FLOORS. DANCE FLOORS. STRENGTHENING AND STRUTTING. OPEN JOINTS. CALCULATING STRENGTHS. L.C.C. TABLES. CONCRETE PATHS AND PAVINGS.

THERE are many materials that can be applied to a floor to provide a top surface suitable for the purpose, but the structural part of all floors falls into one of two main groups: (1) the beam type, where the supporting members are independent and spaced apart from each other, and (2) the solid type, presenting a continuous top surface on which the finishing can be laid.

The solid type floor may rest on the ground, or be suspended, as in the case of an upper storey.

The general principles of the types are shown in Fig. 1.

Throughout this chapter the term *flooring* will be used to denote the actual surface finish or covering, whatever the material may be.

In the beam type, such as the ordinary timber floor, the main constructional members are joists that act as beams spanning from support to support, and are spaced at definite and regular distances, usually 14 or 15 in., from centre to centre.

Timber joists are usually 2 or 3 in. in breadth, and anything from 4 to 10 in. in depth, according to the span and load; and as the load-carrying strength of a beam over a given span depends mainly on its depth, that is, in a direction vertically under the load, joists are placed so that their longer sides are upright.

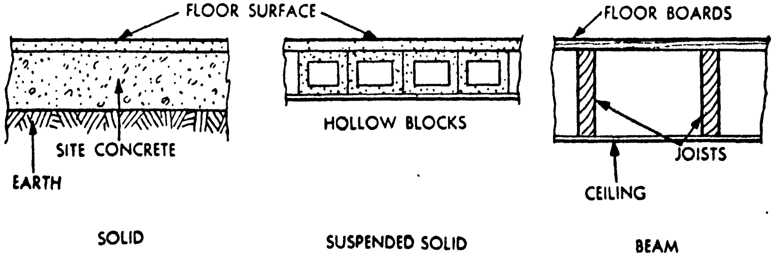


Fig. 1. General principles of the various types of floors. In the solid type the floor may rest on the ground or be suspended as in an upper storey.

The walking surface is provided by laying boards close together on top of the joists, and at right angles to them, but laid flat instead of upright. Thus the boards are also acting as beams spanning from joist to joist, but, as they are laid flat, their depth is small. Their load-carrying strength is not great, and if they are too thin, or the spacing between the joists is too wide, the boards will bend unduly when a load is put on them.

Floor boards are usually 1 or 1¼ in. thick, and 3 to 7 in. wide. Hardwood flooring is usually in the narrower widths and boarding in narrow widths is known as strip flooring.

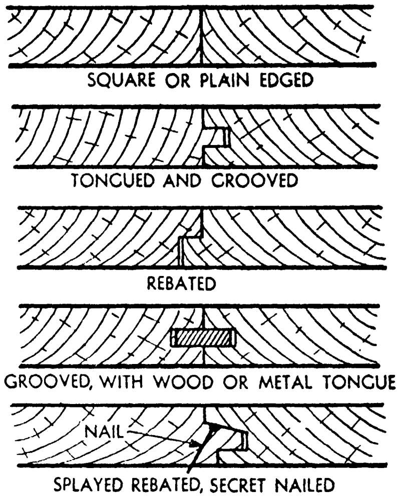


Fig. 2. Types of edge joints which are employed in timber floorings.

Types of Edges

The edges may be square, the boards being laid without any means of closing the joint and preventing the passage of dust and draught; or tongued and grooved, where a projecting strip of the edge of one board fits into a corresponding groove in the next board; or the adjoining edges may be grooved, and a hardwood or metal tongue inserted; or they may be rebated.

Hardwood strip flooring is secret nailed; that is, the fixing nails are driven through the projecting tongue of one board before the rebated edge of the next board is placed in position; thus the heads of the nails are hidden. The various types of edges are illustrated in Fig. 2.

Worn Boards. Where traffic over the floor is heaviest and keeps to more or less definite paths, as at doorways, the top surface of the boarding will be worn down more than in other parts of the room. This will give the appearance of the flooring being hollowed out, and if the wear is considerable the resulting thinness of the boards will cause them to give or bend under the tread, because as beams they are no longer deep enough to carry the required load over their span from joist to joist without undue deflection.

In softwood flooring, the grain usually runs the long way of the boards, exposing expanses of softer wood divided by lines of hard grain. Traffic along the grain wears away these softer portions more quickly than it does the harder, so that the hard grain and knots eventually stand up above the surface of the soft grain. Excessive washing and scrubbing have the same effect as traffic.

To effect repairs, the defective portions of the flooring must be taken up and new boards laid. If the whole of a length of board is not taken up it will be

necessary to cut it at some part of its length, and the cut should be made at the middle of its bearing on a joist, so that the adjoining ends of the old and new boards have half the breadth of the joist on which to rest. If the cut is made between the joists, the ends of the boards will be cantilevering, as shown by dotted lines at A in Fig. 3, and will spring under weight. The correct position of the cut is shown at B.

If the boards have plain butt edges it is comparatively easy to lever them up,, but if they are tongued and grooved the tongue will have to be broken away and the new boards laid with plain edges. Specially shaped saws are made for cutting through floor boards; alternatively, holes can be bored where the cut is to be made, to give a start to a padsaw.

When worn boards are replaced, the new ones will be a little thicker than the old, and so will stand up slightly higher at the adjoining edges, but this can be remedied by planing along the surface near the new edges, although the centre part of the new boards will thereby be made slightly convex.

Shrinkage of Boards. Another condition that may arise is the curling upwards of the edges of the boards. The reason lies in the fact that timber swells when it absorbs moisture, and shrinks when that moisture dries out. But it shrinks across the grain, or what may be called in a direction "round the tree", much more than it does along the grain, or "up the tree". As the width of a board is across the grain, the shrinkage is greater in that direction than along the length of the board.

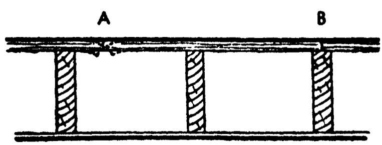


Fig. 3. A. Dotted lines show board cantilevering as a result of cut made between joists. *B.* Cut made in correct position to avoid cantilevering.

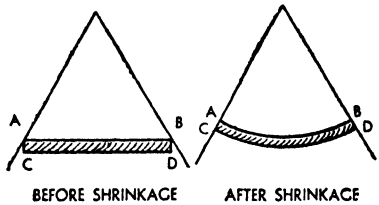


Fig. 4. Curling of board caused by shrinkage. Tonguing and grooving help considerably to prevent this.

Shrinkage means that the board is trying to reduce its width, and as the upper surface is exposed to the warmth and air of a room, it dries more quickly than the under surface, which faces the closed-in part of the floor. Therefore the board tries to reduce the width of its upper surface to a greater degree than its under surface, and the only way it can do so is by curling.

Fig. 4 shows this curling, and it will be seen that whereas before shrinking the upper surface AB of the board was the same width as the under surface CD, after shrinkage the surface AB is less than CD. If the boards are tongued and grooved, the tendency to curl will be to some extent resisted.

When the floor boards are covered with linoleum or carpet, curling will cause ridges to appear, and traffic over them will wear away the covering more quickly than in other parts. From this point of view, curling may be

considered a defect which can be remedied by planing off the upstanding edges.

Dry Rot. One of the most serious defects that can occur in a wood floor is dry rot. It is caused by a fungus which destroys the fibres of timber and finally makes it brittle and decayed. The fungus feeds on timber in moist and ill-ventilated positions, and in conditions favourable to its growth it will spread and affect large areas of wood. It is not likely to attack wood having a moisture content less than 20 per cent. of its oven-dry weight.

The disease causes splits to appear, both along and across the grain, and the cube effect thus produced is characteristic.

Wood affected with dry rot turns a darkish brown, and loses its natural smell. While the fungus is growing it forms white cushions, with patches of bright yellow, and its strands, or feelers, can creep across brickwork to attack timber in other positions.

A likely place for dry rot to appear is in a ground-level floor, as this usually rests on sleeper walls built on the site concrete, and even if concrete is composed of good materials, well mixed and laid with care, there is always a risk of small fissures being present, through which moisture from the earth will rise. Thus the air in the space between the concrete and the underside of the floor boards may become damp; the timber will absorb this moisture and so produce the conditions favourable to the growth of dry rot.

If the sleeper walls are well provided with honeycomb openings, and the external walls have enough air bricks, the circulation of air may be sufficient to carry away the moisture, and so prevent the disease starting, but it often happens that in course of time the air bricks become clogged, or even covered up with garden mould.

Pockets of dead and stagnant air are dangerous, and for this reason the inner recesses next to chimney breasts, and the enclosed space under stairs, are positions in which the disease may commence.

Dry rot may also occur in floor boards that are laid on fillets either embedded in, or resting on, concrete. If the under side of the concrete is exposed to damp this will creep up to the fillets or

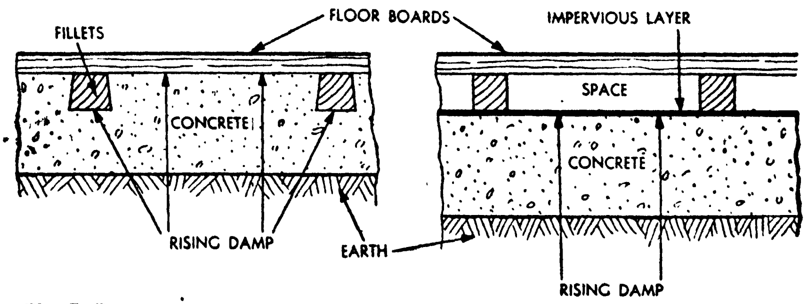


Fig. 5. Dry rot caused through the underside of the concrete being exposed to damp which creeps up the fillets to the floor boards. This can be prevented by the insertion of an impervious layer (*right*) between concrete and fillets.

boards, as shown in Fig. 5, unless an impervious layer has been provided between the concrete and the fillets.

If the floor is covered with linoleum, washing may cause water to reach the boarding, either round the edges of the linoleum, or between the joints, or even through worn patches. The timber will absorb this moisture and have little chance to dry out, because the linoleum forms a practically air-tight covering, especially if glued to the boarding.

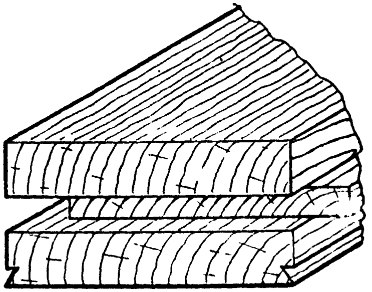


Fig. 6. Wood blocks which have their sides shaped to interlock. They are available in several varieties of wood from deal to oak or teak.

Dampproof Courses

In all cases of dry rot, indeed of dampness generally in ground floors, it is well to see that there is a dampproof course in all walls built into the ground, and that, in the case of sleeper walls, there is one under the wood plates on which the joists rest. Otherwise, damp from the earth will creep up the walls and affect the woodwork. Sometimes earth is piled up against an external wall and covers the dampproof course. As a result the brickwork above the course has no protection against rising damp, and woodwork resting against the brickwork may absorb moisture from the wall.

The best cure for dry rot is to clear away and burn all the infected timber, replacing it with new wood that has been treated with preservatives. If there are strands or feelers clinging to adjacent brickwork they should be destroyed with a blow-lamp.

When the disease has attacked a joist-type floor because of insufficient ventilation, extra ventilation must be ensured by making additional openings in the sleeper walls, taking care to ventilate all dead-air pockets. If necessary, more air bricks should be inserted in the external walls, and even in partition walls, to ensure through ventilation. Built-in ends of joists or beams should be given an air space round them.

Other Diseases

Dry-rot fungus is not the only disease that will attack and rot timber. *Pore fungus* feeds on wood that is much damper than that which attracts dry-rot fungus. *Cellar fungus* only attacks timber that is definitely wet.

Defects in the finishing cover, or flooring, of the solid type of constructional floor such as pre-cast concrete, filler joist and concrete, or hollow tile and concrete, are different from those occurring in the beam type. In the solid type there is a continuous surface on which the flooring can be laid and therefore it does not have to act as a beam.

Wood Blocks. Several floorings may be used. One frequently employed is the wood-block flooring. When this is used, the top surface of the constructional concrete floor is screeded in cement

and sand to a level surface, then a coating of a bituminous compound is applied, on which the wood blocks are laid and pressed together. The blocks have a dovetail cut along their bottom edge, so that the bitumen is forced into the recess during the process of laying, thus helping to keep the blocks down and together. Their sides may be shaped to interlock, as shown in Fig. 6. Sometimes the sides and ends are interlocked with dowels.

Wood blocks may be laid in a variety of patterns, a very common one being the herring-bone pattern, and they are available in several varieties of wood, from ordinary deal to the harder and more decorative woods such as oak and teak.

Defects in this type of flooring are usually the result of long and hard wear. As these blocks are not acting as beams, any particular block can be taken up without affecting the strength of the floor, and however much they may be worn they will not give under the tread, as will worn boarding which has been laid over joists.

An important point in laying a wood-block floor is to leave room for expansion between the edges of the flooring and the walls. The blocks come on the job dry, and are, therefore, ready to absorb any moisture in the atmosphere. This causes them to expand, and if there is no room for expansion the flooring will arch up. It is usual to finish the flooring at the edges with a border of one or two rows of blocks laid parallel with the walls. This border should finish about 1 in. away from the wall, and the space filled in with sand, cork strips, or springs set at frequent intervals. The skirting, or kicking fillet, will cover this expansion joint.

In carrying out repairs there are one or two points that call for consideration. One is the manner in which the block has been cut from the log. If *flat sawn*, as indicated in Fig. 7, the grain runs in the long direction of the block

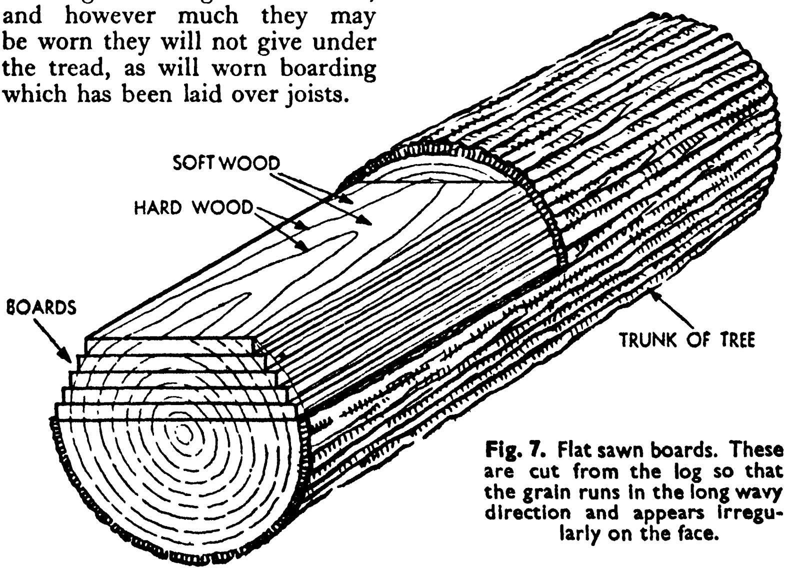


Fig. 7. Flat sawn boards. These are cut from the log so that the grain runs in the long wavy direction and appears irregularly on the face.

and will appear irregularly on the face, the wood between being of a softer nature.

This soft wood may splinter and become a source of danger to persons walking over it. Such defective blocks should be taken up and replaced with new.

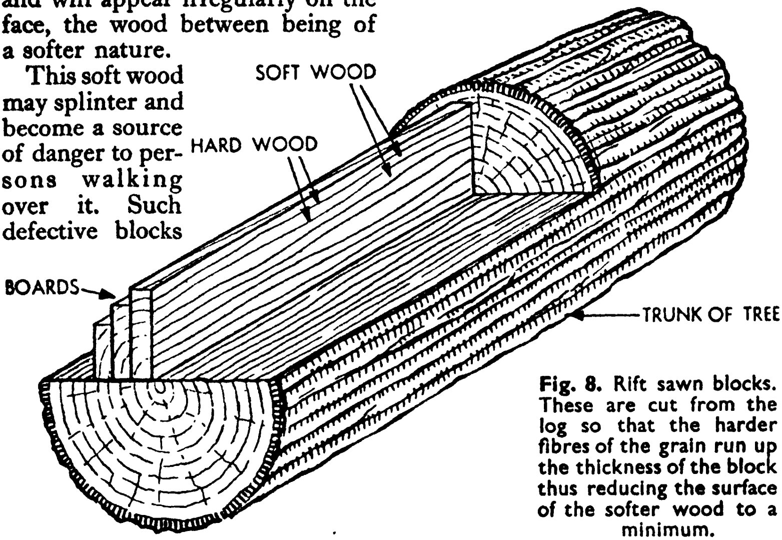


Fig. 8. Rift sawn blocks. These are cut from the log so that the harder fibres of the grain run up the thickness of the block thus reducing the surface of the softer wood to a minimum.

For hard and even wear, blocks should be *rift sawn* (Fig. 8), that is, so cut from the log that the harder fibres of the grain run up the thickness of the block; the surface of the softer wood is thus reduced to a minimum. When wood-block flooring is badly worn over most of its area, it can be improved by being re-surfaced with a planing machine. This machine has an electrically driven rotating planing device and is mounted on wheels. As it is wheeled over the floor the upstanding portions are planed off until a general level is obtained.

New floors are often surfaced with a sanding machine, which operates in much the same way as the planing machine, but has a roller covered with abrasive or sand paper. As it revolves, it lightly scrapes the top surface of the flooring. The fresh surface exposed by the treatment should be given a dressing with one of the oils or wax polishes which floor specialists generally supply.

Strip Flooring. Another method of providing wood flooring over a solid constructional floor is to put down fixing fillets on which lengths of narrow-width boarding are laid. The boards are usually cut from one of the decorative hardwoods, such as maple or oak, and are in widths of 3 to 4 in. For cheaper work, British Columbian pine is frequently used.

When laid on a suspended floor, strip flooring is not likely to suffer from the effects of damp, but if any defects arise, they will most probably be due to ordinary wear, in which case replacement of the defective boards will put the matter right again.

If, however, this flooring is laid on a solid floor at ground level, trouble may be caused by damp rising from the earth, and much will depend on the manner in which the fillets have been laid.

They may be embedded in the concrete of the sub-floor, with their top surfaces a fraction of an inch above the general level of the concrete; or they may rest on top of the concrete and be fixed with the metal clips that are made for such a purpose; or they may be fixed with clips and have the spaces between them filled with fine breeze or pumice concrete.

When the fillets are laid in or on the concrete without a protective coating of impervious material such as bitumen, there is a risk of damp reaching them and the under side of the flooring, thus causing dry rot. It will often be found that ventilation has not been provided, as indeed it cannot be, if the fillets are either embedded in the concrete or filled in with fine concrete.

If, on opening up a floor, the fillets are found to be resting on top of the sub-floor, without any filling, there is an opportunity of providing at least some ventilation by cutting short lengths, say an inch or so, out of them at

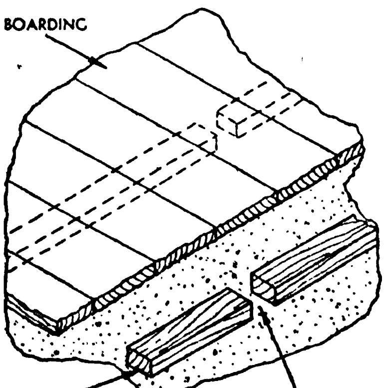


Fig. 9. In this method of providing ventilation lengths of about 1 in. are cut out of the fillets at frequent intervals to allow air to pass under floor.

frequent intervals, as shown in Fig. 9. Gratings should be fitted in the skirting, or at the extreme edges of the floor, to allow air to get down to the fillets and pass along under the whole of the flooring, through the openings, in the same way as it would through the honeycomb openings in sleeper walls.

Should such flooring need to be taken up and relaid, this provision of ventilation should be made, to minimise the chance of an outbreak of dry rot. The under side of the flooring may be tarred, as an additional precaution.

As an overlay to deal floor boarding on joists, *thin strip flooring* is excellent. But as the thickness of hardwood strips is only $\frac{3}{8}$ in. or so, they should not be laid direct on the joists. Counter boarding should always be laid first, and the strips fixed thereto.

Decorative Wood Flooring

Parquet. Perhaps the most decorative of all wood floorings is parquet, as it can be laid in simple or elaborate designs and with contrasting woods. As the individual pieces are thin, about $\frac{1}{4}$ in., woods can be used that would be expensive if laid in blocks of normal thickness.

Parquet is often used to cover an old wood flooring. In such a case the old surface is thoroughly cleaned off and the parquet laid down and kept in place with panel pins and a cementing solution.

When defects arise, the old flooring is most probably the cause, as it may expand or contract owing to changes in atmospheric conditions. If it contracts, the parquet overlay will be thrown up into ridges or waves. To prevent this it is necessary to isolate

the parquet as far as possible from the movement of the sub-floor.

The simplest method is to nail sheets of 3 or 5 mm. plywood to the old flooring and lay the parquet on the plywood, taking care to plane or scrape away any upstanding portions of the old flooring, such as curling edges of the boards.

Plywood is very useful for covering an old wood floor where not subject to hard wear and tear which would otherwise need a good deal of repair. It can be laid either as the final flooring, or as a base for parquet strip flooring, linoleum or rubber. When intended to form the final flooring, plywood faced with a decorative wood, such as oak or birch, would naturally be used.

Where the old floor is reasonably even, the plywood can be glued and panel-pinned direct to the floor, but where there is much unevenness it is advisable to level up with mastic and use 5 or 6 mm. plywood. In positions where there is a danger of damp rising, a resin-bonded plywood should be used. When laid over a wood-joisted floor the grain of the outer ply should run over the joists.

Plywood need not necessarily be laid over the whole surface of a floor. If the floor is to be partly covered by a carpet, a surround can be formed in plywood.

Treatment and Repair

It is advisable to wax polish plywood if it forms the actual top surface of the floor, as this fills the pores and prevents the entry of dust and dirt and adds considerably to the life of the floor surface.

Staining will often add to the appearance by throwing up the grain in colour relief, but if the upper surface is to be stained, or polished, or varnished, it is well to paint the under side, so as to equalise any tendency to expansion or contraction of the top surface, resulting from the treatment.

Sizes of standard sheets vary according to the kind of wood used, but normally run up to 4×8 ft.

If plywood needs repair, the whole affected panel should be renewed, as the construction of the sheets renders repair to the outer surfaces an unpractical operation.

Defects in Linoleum

Linoleum. Defects needing repair in linoleum are principally cracking and lifting, apart, of course, from wear due to long use. If the sub-floor is of wood boards, and they curl at the edges, the linoleum is forced up into ridges, which soon crack and wear through under traffic.

It is usual to cement or glue the linoleum to the sub-floor surface. If damp reaches that surface the cementing material is affected, adhesion broken, and the linoleum lifts at the edges. In such cases a permanent cure cannot be expected unless the cause of the dampness has been removed, or its effects prevented, and this depends on the particular circumstances of the case.

Composition Flooring. There are several other materials, besides wood and linoleum, which can be used as a surface finish to a solid floor. These include composition flooring, terrazzo, granolithic, cement, concrete, rubber, cork, tiles and asphalt.

Composition, or what are often called jointless, floorings are usually laid on a concrete sub-

floor. Defects that may arise are cracks, sweating and actual breaking-up of the surface.

These floorings usually contain magnesium oxychloride, often with a mixture of wood flour. All of them are laid wet, and as the contained moisture dries out, shrinkage takes place. Good adhesion of the flooring to the concrete sub-floor resists this shrinkage, but if for any reason the adhesion fails, cracks may appear. If newly laid, the concrete sub-floor itself may crack on drying out, in which case the composition flooring is almost certain to crack with it.

As these floorings are formed of special materials, mixed in varying proportions, it is best to call in a specialist firm to repair cracks. They can be cut out and filled with the same material as the flooring, although it will be difficult to hide the lines of the cracks.

Sometimes these floorings are laid in bays of comparatively small areas, divided from each other by thin strips of some material not likely to be attacked by the chemicals contained in the mixture. Ebonite strips are often used for this purpose.

The small areas of the bays tend to lessen the risk of cracking, but as one of the main purposes of jointless flooring is to provide a continuous surface, the presence of the dividing strips may not be approved.

Faulty Adhesion

In extreme instances the adhesion of the flooring to the sub-floor may fail completely; in such an event shrinkage on drying-out will be unrestrained, and the flooring may crack up. Occasionally, patches will lose their adhesion, swell up like a bubble, and break under traffic. Here again it is a case for the services of a firm specialising in such floors, and if the flooring has been laid in small bays, repairs may possibly be necessary only to one or two bays, instead of the whole floor.

Sweating. Sweating is due to the nature of the flooring. The salts used in the mixture are hygroscopic, that is, they readily absorb moisture, and if the atmosphere of the room is charged with moisture this will be attracted by the composition, and a damp surface will be the result.

If the flooring is laid on concrete at ground level, dampness from the earth may rise through and affect the composition.

Damp Penetration

Jointless floorings are usually wax polished or oiled shortly after they have been laid, and when thus treated at regular intervals the trouble should be greatly lessened.

When it is proposed to lay jointless flooring on a wood sub-floor, galvanised wire netting should be stretched across laths nailed to the sub-floor. This acts as a reinforcement resisting shrinkage. Expanded metal lathing may also be used, and, as a precaution additional to galvanising, it is well to coat it with bitumen, to prevent the flooring from coming into contact with the actual metal of the reinforcement.

Terrazzo. All materials containing cement are liable to slight expansion or contraction, due to changes in temperature and to shrinkage due to the drying-out of the water used with the cement. Terrazzo floorings are from $\frac{5}{8}$ to

$\frac{3}{4}$ in. thick, and are composed of fine aggregate, cement and a top surface of chippings, generally marble, or hard limestone. Cracks may therefore appear as the cemented mixture contracts on drying, especially if a large amount of water was used when mixing took place.

It is not easy to repair cracks in a sightly manner, owing to the special and decorative nature of the chippings forming the upper surface and the colour of the cement used, but if it is essential that the cracks should be filled in, it can be done by rubbing in a fine cement cream.

The line of the cracks will be obvious against the terrazzo, but at least the entry of dust and dirt into the cracks will be prevented. Here again, laying the flooring in small bays, with dividing strips, limits the trouble. Terrazzo floorings are polished smooth by rubbing with a hard stone and water.

Granolithic. A granolithic flooring is similar to a terrazzo, but the chippings are smaller, and usually of granite, as the name suggests. When given a top dusting of carborundum a non-slip surface is formed.

Causes of Cracking

The most probable cause of cracking is lack of adhesion of the granolithic to the concrete sub-floor, especially if the latter is too smooth to give a good key.

The unavoidable shrinkage when drying imposes a stress on the adhesion between the granolithic and the sub-floor, and if adhesion holds in one part of the floor and not in another, cracking will occur. Shrinkage may force up the granolithic into a bubble, which will sound hollow, and eventually this bubble will break up. In repairing small patches, the loose material should be cut out in a rectangle, taking care to cut clean, straight edges. The patch can then be filled in with new granolithic.

If adhesion fails over most of the floor surface, the granolithic will eventually break up into pieces. In such a case, the only remedy is to take up all the granolithic and relay it; and if the concrete sub-floor is found to be smooth, it should be hacked to provide a good key for the new material, all fine particles swept up, and the surface wetted before the new granolithic is laid.

Where steel joists are used in a floor, cracking often occurs over the joists, and there may be two reasons for this. Either temperature changes are causing expansion and contraction to occur in the joists, and the granolithic is not sufficiently elastic to give with the changes, or it may be subjected to tensile bending stresses where it passes over the joists.

Granolithic floors laid in panels may show signs of curling at the edges. The top surface may dry out more quickly than the lower, as it is exposed to the warmth of the room; the flooring therefore curls for the reason previously explained in this chapter.

A granolithic top flooring should not be less than 1 in. thick, and a suitable mix is 1 part of Portland cement to $2\frac{1}{2}$ parts of granite chippings that will pass a $\frac{1}{4}$-in. mesh.

When laid on an old concrete floor, the old surface should be thoroughly cleaned and given a brushing with cement and water just liquid enough to be worked easily. The topping can then be laid and finished with a steel float.

The flooring should be left undisturbed for at least ten days before being subjected to the strain of traffic.

Cement Flooring. Floorings of plain cement and sand are usually about 1 in. thick, and mixed in the proportion of 1 of cement to 2½ or 3 parts of sand, which should not be sharp or too fine. They are liable to the same defects as other types of flooring containing cement, and for similar reasons. As special or decorative materials are not used, it is easier to fill in cracks without making the repair look very unsightly. Even so, the patching will probably show.

If the flooring bulges and cracks so badly that the only satisfactory remedy is to take it up and lay a new one, special attention should be given to the condition of the top surface of the concrete sub-floor.

It frequently happens that the concrete sub-floor was laid some time before the general progress of the building allowed the final flooring to be put down. The surface of the sub-floor would, therefore, have been dirtied by the boots of workmen; thus the floor would be covered with a thin layer of dirt or clay, or even plaster droppings.

Surface Treatment

Such a surface would prevent good adhesion between the sub-floor and the final finish, and there would be little to resist the contraction of the finish on drying. A thorough scraping with a wire brush will remove the crust of dirt.

This treatment will also help to clear away the *laitance* in a concrete floor, that is, the thin top layer which contains more cement and fine particles than the remainder of the floor. As the aggregate in concrete consists of particles of varying sizes, there is a tendency for the heavier pieces to sink towards the bottom when the concrete is deposited, and the action of trowelling, or spade-finishing, the surface squeezes the wet cement and fine particles to the top. This laitance has little strength and is easily detached from the larger pieces of aggregate beneath. Traffic soon breaks away this weak top surface, a process usually known as *dusting*.

Prevention of Dusting

This condition can be prevented to some extent, by applying a hardening solution. The application of two or three coats of a weak solution of sodium silicate will usually be found to give a satisfactory result. A suitable strength is 1 gallon of water-glass solution to 4 gallons of water.

Rubber. Troubles that may be expected in a rubber flooring are the usual ones of lifting at the edges, or general loosening. It is not easy to obtain good adhesion between rubber and concrete which is in the least damp, and in the case of a concrete sub-floor resting on the ground the top surface may appear to be quite dry, because evaporation takes place there more quickly than the damp from the ground can rise through the concrete. If the top surface is covered with an impervious material such as rubber, this evaporation cannot take place, and rising damp will cause moisture to collect between the top of the concrete and the under side of the rubber.

This moisture will break down the adhesion, and it is useless to try to stick down the lifting edges

of rubber flooring if the cause of the trouble has not been removed.

The proper remedy is to take up the flooring and coat the concrete sub-floor with bitumen or asphalt before relaying the flooring. Indeed, if the floor is at ground level, asphalt should always be laid on a concrete floor before the rubber is put down.

Lack of adhesion is not likely to occur in the case of a suspended concrete sub-floor, as it is not subject to rising damp, and if the flooring should lift it is probably because it was laid before the sub-floor had time to dry out thoroughly.

Preparation of Sub-floor

When it is proposed to lay rubber flooring on a wood sub-floor, the surface of the boarding should be quite smooth and even, otherwise the rubber will show up irregularities. Nail heads should be punched in, knot holes filled, and all dirt and grease removed.

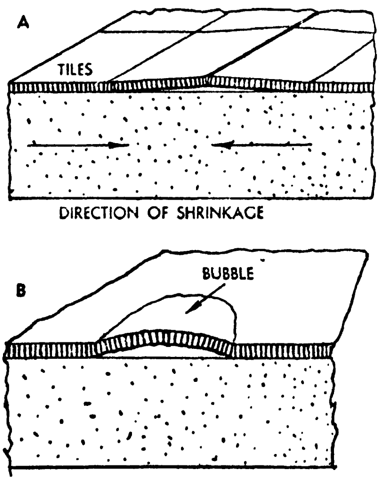


Fig. 10. A. Arching caused by contraction of concrete sub-floor. B. Bubbling in asphalt flooring due to the unsatisfactory surface of the sub-floor.

It is advisable to cover the sub-floor with plywood, before the rubber is laid, if there is any likelihood of the original floor warping.

Cork. Cork flooring is liable to the same defects that occur in rubber flooring, and the same considerations apply when carrying out remedial measures.

Tiles. Tiled floorings sometimes buckle and become arched in places, giving out a hollow sound under the tread.

The chief requirement in tiles used as flooring is that they should be hard and impervious, and therefore not subject to much shrinkage after manufacture.

Tiles are usually laid on a concrete sub-floor, which is liable to movement under atmospheric conditions. When the sub-floor contracts it tends to pull the tiles together, but as they cannot be compressed, this movement causes them to break their bond with the sub-floor, and arch, as shown at A in Fig. 10.

Tiles are seldom made with a back specially shaped to give a good key with the sub-floor, as even if there are grooves in the back they are seldom dovetailed. Consequently, there is little mechanical help in maintaining adhesion of the tiles to their bed.

Tiles are laid with a fine joint, which is filled in with neat cement, but the action of pressing them into position forces some of the bedding material into the lower part of the open joint, and this material has not much strength to resist disruption.

Some tiles are slightly wedge-shaped, the top surface being a little bigger than the lower; thus the top edges of adjoining tiles are closer together than the lower,

and therefore arching takes place more easily.

When the condition of a tiled flooring has become so bad that the only proper remedy is to take it up and relay, it is a good plan to re-bed them with a slightly wider joint, so that there is room to fill in with a cement-sand mixture of the usual kind.

Quarry tiles are usually 9 by 9 in., or 12 by 12 in.; tessellated, 6 by 6 in. and smaller sizes of varying shapes so that patterns can be formed, the usual thickness being ½ in.; vitreous tiles are harder, but usually not larger than 3 by 3 in., as larger sizes are apt to get out of shape when fired. Tiles should be set with a ½-in. backing coat of cement and sand.

Asphalt. Formerly, the usual greyish-black colour of asphalt was thought to be somewhat sombre for interior use, but within comparatively recent years coloured asphalts have been put on the market.

With their advent, asphalt began to have an extended use for flooring, especially in situations where water is liable to be spilt on the floor. It can be laid either in its mastic state, or in the form of ready-made tiles.

The material is excellent for laying on a concrete sub-floor which is in contact with the ground, as it forms an impervious layer against rising damp.

When laid on a sub-floor formed with steel joists, it is wise to put a slip-layer, say of building paper, over the line of the joists, especially if their upper flanges are exposed. This will allow the joists to move under temperature changes without cracking the asphalt, although the material is sufficiently elastic to permit slight movement of the steel without ill effects.

Asphalt occasionally leaves its bed, and may bubble in places if the top surface of the concrete sub-floor is not satisfactory, as shown at B in Fig. 10. Bubbles, cracks and splits may be easily remedied by cutting away the asphalt round the defective portions and applying hot mastic to the newly-exposed edges. This softens the edges, and a patch of new asphalt can be laid which will make a good joint with the old.

Asphalt flooring can be laid on sub-floors other than concrete, but if used on a timber foundation it is best to cover the old floor with wire mesh, such as chicken-wire, as this acts as a reinforcement to the asphalt flooring.

Timber Floors

The usual type of wood floor, consisting of a single system of joists to which the floor boarding and ceiling laths are nailed direct, is suitable for the average house and small business premises. However, where the width of the apartment is comparatively great, or the load to be put on the floor is heavy, the size of joists required would involve an uneconomical use of timber.

In such cases the difficulty is overcome by installing a double floor, that is, dividing the length of the apartment into bays by means of what are called *binders*, which are beams of timber or steel strong enough to support ordinary-sized timber joists and their load. The binders, in fact, perform the same function as walls do in a single-joist system. In a double floor the joists are generally known as *bridging joists*.

The bridging joists rest on the

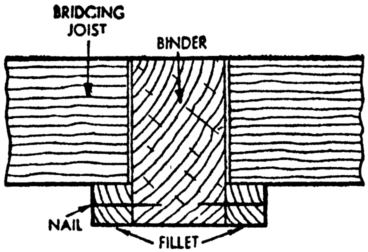


Fig. 11. Bridging joist resting on fillet nailed along the bottom edge of a wooden binder. This is a bad form of construction as the nails through the fillet actually support the joists.

binders, and the manner in which they do so depends on the class of workmanship that has been put into the construction.

A bad form of construction is to nail a fillet along the bottom edge of the binder, if of wood, and to let the bridging joist rest on the fillet, as shown in Fig. 11. It will be seen that the nails through the fillet are really supporting the bridging joist, and if they should fail the joist would fall.

In carrying out repairs to such a floor, it may be found that the nails have given a little, without causing a dangerous condition; if so, the floor can be strengthened by taking up the boards over the binder and driving additional nails through the fillet.

In the less expensive types of houses this method is sometimes used where there is a bay, and a beam has been used to carry the main part of the floor on one side and the joists in the bay on the other.

When the thickness of the floor is not of importance, it is better practice to cog the bridging joists over the binder, as shown in Fig. 12 A.

If the joists are long enough to be cogged over one binder and continue to the next, the bevelled halving shown in Fig. 12 B forms a good joint for the meeting of the next run of joists.

In this form of construction it is possible that in the course of time the joists may work a little loose in the cogging, and may rise and fall under the effects of traffic over the floor. This may give rise to

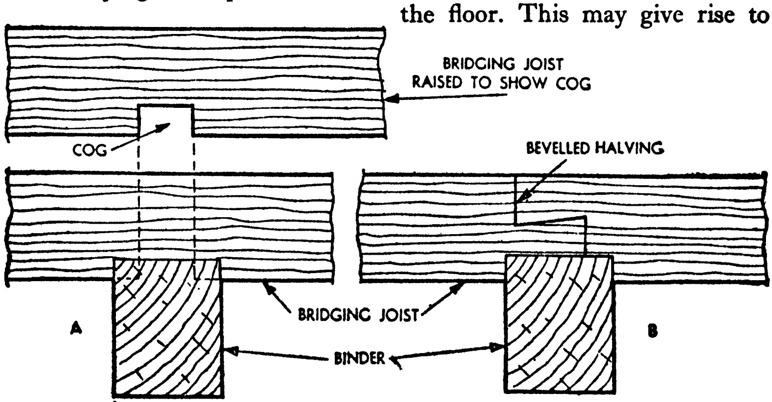


Fig. 12. A. Method of cogging bridging joists over binder. B. Bevelled halving employed to form a good joint for meeting of next run of joists.

squeaks or slight tapping sounds as the joists hit their seating again after rising. This can be remedied by taking up the flooring over the binder and nailing the joists tight to the binder.

It may be that at the time of construction it was desired to have a floor as shallow as possible, in which case it will probably be found that the bridging joists have been housed into the binder, either with a plain, or preferably dovetailed, housing. The two joints are illustrated in Fig. 13. This method of jointing allows the top surface of bridging joists and of binder to be flush.

There is less likelihood of the bridging joists rising and falling in this type of construction, especially if the housing is dovetailed, as they are not quite so free as when cogged over the binder.

Fig. 14 shows a typical notching when the binder is a rolled steel joist. The bridging joists are shaped to rest closely on the upper surface of the lower flange, but are kept a little clear of the rest of the r.s.j., to allow for expansion and contraction of the timber. Thus the shaped ends of

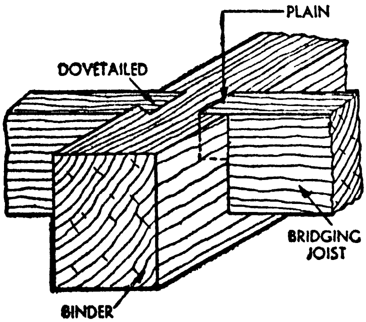


Fig. 13. Plain and dovetailed housing. This method of jointing brings the top surface of the bridging joists flush with the top surface of the binder.

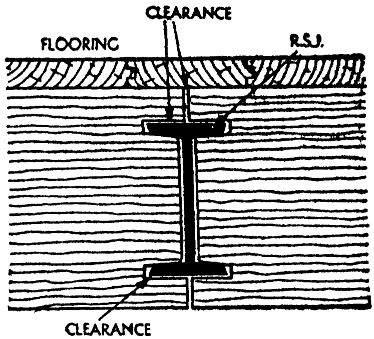


Fig. 14. Typical notching when the binder is a rolled steel joist. Bridging joists are shaped to rest closely on the upper surface of the lower flange.

the upper part of the wood joists do not quite touch the upper surface of the top flange of the r.s.j. The shaped upper ends of the bridging joists are really acting as small cantilevers projecting from the main body of the joists, and if these projecting portions are very shallow in depth, a heavy weight passing over may cause them to depress. If these adjoining edges are touching one another, the bending movement may give rise to squeaks. Cutting off a little strip from the ends of the joists would cure this, but would involve taking up the floor board over the r.s.j.

An advantage of a double floor is that the plaster ceiling is less likely to crack. In the single-joist system the laths are nailed direct to the under side of the joists, and if there is any considerable movement of the joists, the plaster, not being elastic, cannot give with the movement, and therefore it is inclined to crack.

With a double floor, the lath-and-plaster ceiling is usually nailed to a separate system of ceiling joists, either direct to the bottom

of the binder, or notched over it. As the ceiling joists are of comparatively small section, the extent of their expansion and contraction is proportionately small, and the plaster is not put under great tension.

If, however, the binder is allowed to show as a beam in the ceiling below, the laths will then be nailed to the bridging joists in the usual manner, and cracking of the plaster may result.

Sound Insulation

Of late years considerable attention has been paid to the question of preventing noises penetrating from one room to another, above or below.

The usual type of floor, with joists carrying floor boarding above and lath and plaster underneath, resembles a drum; and sounds of footsteps, and even of conversation, may be transmitted by the floor system. To obviate this, methods have been introduced in which the upper part of the floor is isolated from the lower, to stop the transmission of impact noises.

One such system employs a solid sub-floor, such as a concrete floor, and on this is laid an independent floor consisting of flooring laid on fillets which rest on the concrete. To the underside of the fillets rubber buffers are attached at intervals, and these act as cushions when traffic over the upper floor presses it down on the sub-floor. Loading slabs are laid on the shoulders of the fillets to resist any tendency of the upper floor to bounce.

It would hardly be right to call this transmission of sound a defect in a timber floor, but the occupiers of the premises may well consider it a nuisance, and may wish to reduce it as much as possible.

If it is not desired to go to the cost of taking up the floor and installing a special one, it is possible to lessen the nuisance by pugging the floor; that is, inserting a layer of ordinary concrete, or breeze concrete, or slag wool, between the joists. This to some extent stops the drumming effect. Slag wool is the best material to use, as it adds very little weight to the floor.

It will be necessary to pull up the wood flooring boards at intervals and insert a layer of the wool, some 3 in. thick, resting on the ceiling below, and leaving an air space between the top of the wool and the underside of the boards, as shown on the left-hand side of Fig. 15.

The wool acts as a damper to the sound waves, but as there is still direct connection between the flooring and the ceiling by means of the joists, perfect results cannot be expected.

A slightly better method is illustrated in the right-hand side of Fig. 15, because an air space is left both above and below the wool. Fillets are nailed to the sides

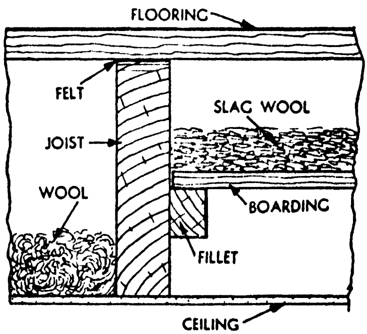


Fig. 15. Two methods of sound insulation between floors in which slag wool is employed as the sound damper.

of the joists and boarding is laid on the fillets, as a support for the wool.

As this necessitates taking up the flooring, it will be an additional help if strips of thick soft felt are laid on the top of the joists before relaying the floor boards. This will isolate the boards from the joists, but even so the nails will give direct connection between the boards and the joists.

Dance Floors

The general principles of a floor intended for dancing do not differ from those governing a strip floor laid on fillets, but the important point is the support of the fillets. The object aimed at is to provide a resilient floor that will not give or sag appreciably under the weight of a person standing still, or walking in an ordinary manner, but will do so under the wave motion set up by the rhythmic movement of persons dancing. The usual method of attaining this end is by resting the floor on springs, their tension being adjusted to give the required resilience.

The main sub-floor should be of a rigid character, to ensure that only the springs provide the resilience. The actual flooring is commonly provided by strip flooring of long and narrow boards from a hardwood such as oak or maple. The fillets carrying the strip flooring are supported on cross beams, either of timber or steel, as shown in Fig. 16, while the beams are carried by the springs.

Other systems employ rubber buffers under the beams instead of springs, but for large floors carrying a great weight the spring system is more suitable.

As the smoothest "feel" to the feet when dancing is given when going with the grain and not across it, the strip flooring should be laid with the long way of the boards running down the long side of the hall. Thus the dancers have to dance across the grain for the least distance, which is the breadth of the hall.

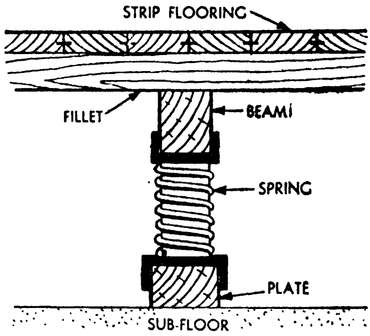


Fig. 16. General principles of dance floor construction. The floor rests on springs adjusted to give required resilience. Fillets carrying the strip flooring are supported on cross beams which are carried by the springs.

For small halls a reasonably resilient floor can be attained by laying a double system of fillets spaced rather wider apart than usual. Thus the floor will be less rigid than is normal, and will give a sensation of springiness. The general principle is clearly illustrated in Fig. 17 on the following page.

Defects that may arise in the surface flooring of a dance hall are similar to those that occur in any other type of strip flooring, but as the boards are usually carefully selected, and the traffic over them is not so continuous or of the same nature as in other kinds of usage, signs of excessive wear should not become apparent for a considerable time.

Solid-type floors are usually

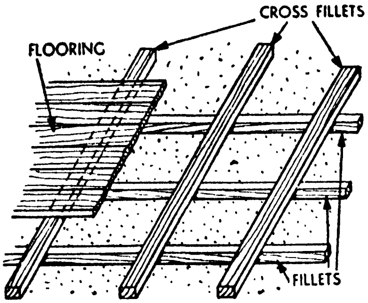


Fig. 17. Further method of constructing dance floors for small halls. In this case a double system of fillets is employed. More spring can be given to the floor if the lower fillets are only supported between the upper fillets.

designed as complete bays and beams, and it is necessary to study the original calculations before attempting to strengthen them.

A timber floor is a different proposition, as each joist can be considered independently. Such a floor may require strengthening for one or two reasons.

If the joists are built into a wall without an air space around their ends, these may absorb moisture and, being unventilated, begin to rot at their seating, although the other parts of the joists may be sound. To renew the joists entirely would, of course, involve all the work of taking up the flooring and destroying the plaster ceiling below.

If it is not desired to do this, the weakened ends of the joists can be relieved of their load by placing a relieving beam tight against the plaster ceiling, parallel to and a short distance from the wall in which the joists rest, as shown at A in Fig. 18. This is on the assumption that objection would not be raised to the appearance of the beam showing below the ceiling, and that the arrangement of the room would permit a proper seating to be given at each end of the relieving beam.

A better method is to cut away the plaster ceiling on the proposed line of the relieving beam, and fit the beam tightly against the underside of the joists. The plaster can then be made good up to the beam, and a cover moulding may be fixed to hide the junction, as indicated in Fig. 18 B.

A floor may need strengthening, not because of any defect in itself, but because it is being made to carry a load greater than that for which it was designed. In such circumstances the floor may sag to a perceptible degree.

This situation can be eased in one of two ways; by reducing the span of the joists, or by reducing the load on each joist without altering its span. The first method involves fitting a relieving beam under the floor, thus reducing the length over which the joists have to span unsupported.

Before inserting the relieving beam, the room above should be emptied, to allow the floor to regain its original level; otherwise the relieving beam will merely prevent the sag from getting worse, instead of preventing its occurrence.

Reducing the Load

The method of reducing the load on each joist without altering its span is carried out by taking up the flooring, removing any strutting between the joists and inserting a new joist between each pair of old joists. As the area of floor carried by each joist is thus halved, so the load on each old joist is also halved.

It will be necessary to form pockets in the supporting walls

to receive the new joists; and if the old joists have been notched for electric-light conduit or other piping, the new joists must be similarly notched, inserted on the slant, and then swung upright when the notchings are under the conduit.

Both methods involve a certain amount of cutting away and disturbance of existing work, but the second method avoids a beam showing under the ceiling. It may not be easy to give a beam a proper and safe seating at both ends; one end might have to rest on a thin partition wall not strong enough to bear the load safely. In such a case it would be necessary to insert a post or stanchion to transmit the load to a secure and sufficient foundation below.

In both methods it will be necessary to ascertain that the load on the floor will not still be too much, even when strengthened.

The foregoing remarks apply to cases where the joists themselves are not strong enough to carry the load which is put on them. If the floor boards give and sag between the joists, because long and hard wear has worn them thin, the substitution of new and thicker boards should solve the problem.

Strutting. Although strutting is now usually fitted between joists, it may happen that a very old timber floor is found to be without it, in which case the floor may give an uncomfortable feeling of insecurity when walked on. This is due to the joists tending to tip sideways under movement, especially if the floor boards have not been nailed to every joist. Considerable improvement can be effected by taking up the flooring and inserting rows of strutting every 6 or 8 ft. along the length of the joists.

Open Joints. Most building operations involve the use of water, and therefore the atmosphere in a building during construction is laden with moisture. If floor boards are stacked in a building for a time, awaiting laying, they will absorb this moisture and expand; and when laid in this condition, the joints between the boards will remain tight and close until the building begins to dry out. The boards will then slowly give up their

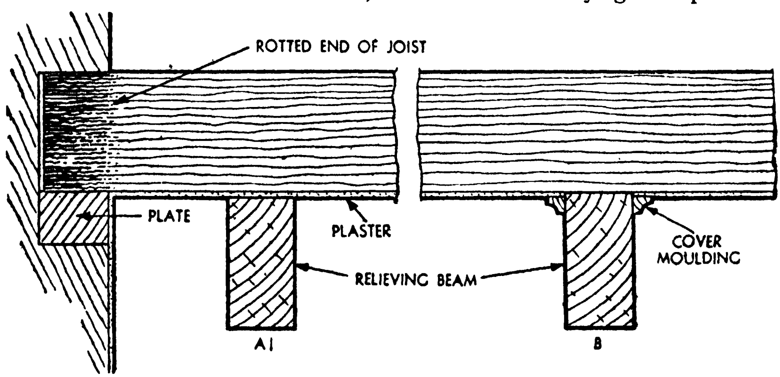


Fig. 18. Methods of strengthening weakened joists. *A.* Relieving beam placed tightly against ceiling to relieve ends of joists of their load. *B.* In this method plaster ceiling is cut away and beam fitted directly against underside of joist.

contained moisture and shrink in their width, causing the joints between the boards to open.

If these open joints are wide, it may be possible to insert thin strips of wood and plane or scrape them flush with the general surface of the flooring. But if the open joints are too narrow to render this procedure practicable, the alternative is to take up the flooring and relay it, taking care to cramp the boards tight against each other.

It is useful to be able to calculate the load that will rest on the various members of a flooring system and the size of the joist necessary to carry that load safely, but it is not advisable to deal with any but the simplest cases without some knowledge of the theory of constructional design.

Definition of Terms

Before considering calculations, however, a few definitions may be found useful.

Load is the weight a beam or joist has to carry.

Distributed load. Weight evenly spread along a beam.

Point or concentrated load. Weight concentrated at one point or position on a beam.

Dead load. Weight of the material forming the beam and the flooring system, and other structural parts that it has to carry.

Superimposed load. Weight brought on the floor by furniture, goods, persons and so on.

Clear span. The distance between the edges of the supports on which the beam rests (Fig. 19).

Effective span. (1) The distance between points half way along the seating of the beam at each end; or (2) in the case of a wood beam, the clear span plus the depth of the beam at the supports, whichever of (1) or (2) is the greater (Fig. 19).

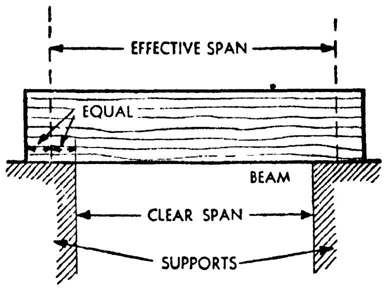


Fig. 19. Diagram illustrating the definition of effective and clear span.

Effective depth. In the case of a wood beam, it is the actual depth of the beam.

Stress. Equal and opposite action and reaction taking place between two parts of a member due to an applied load.

Strain. Change in shape or dimensions of a member resulting from stress.

Breaking weight. The least load that will cause a beam to break and collapse.

Safe load. The load that may safely be put on a beam.

Factor of safety. Factor by which the breaking weight is divided, to arrive at the safe load. In timber it is usually taken as 6, so that not more than, say, 4 cwts. would be put on a beam when calculations show the breaking weight to be 24 cwts. The factor of safety is intended to make allowances for hidden flaws and weaknesses in the timber.

Deflection. The amount by which a beam bends under load. Theoretically all beams bend under the lightest load, even if imperceptibly. The London County Council By-laws require that the calculated deflection of a beam shall not exceed $\frac{1}{360}$ of its

length. Thus a beam 15 ft. long must not sag more than half-an-inch. The "l/d" figures in the L.C.C. tables give the ratio of length over depth that is required in order to prevent any undue deflection.

Strength under Loading. A beam will carry twice the load, if distributed, that it would if the load were concentrated as a central point load.

Assumed Loadings

It would, of course, be out of the question to try to calculate in advance the weight of the various articles of furniture and goods that may eventually be put on the floor, or the weight of persons likely to walk on it. The various regulations, therefore, set out tables of assumed loadings for different classes of buildings, and the floor must be designed to bear such loading safely. The assumed loadings are expressed in pounds per square foot of floor area.

Thus, in the case of rooms used for residential purposes, the London Council County stipulate an assumed superimposed loading of 40 lb. per square foot of floor area, and 80 lb. for the upper floors of an office building. This is in addition to the dead load.

Take, for example, the case of an ordinary timber floor forming the first floor of a house. Assume the room to be 16 ft. long and 12 ft. wide, with joists 2 in. broad spanning across the narrow way of the room and spaced 14 in. apart, centre to centre, and bearing 4 in. on the supports at each end. The clear span of the joints will be, therefore, 12 ft., and their effective span will be 12 ft. plus twice $\frac{4}{2}$ in., that is, 12 ft. 4 in.

The joists support the floor boards on which the superimposed load rests. From Fig. 20 it is apparent that each pair of joists A–B and B–C takes the load coming on the boards resting on them, therefore joist A is taking half the load coming between it and joist B, and joist B is taking the other half and also half the load between B and C. Thus each joist has to carry half the load coming on each side of it, for its whole length.

Joist B, for example, must bear the load coming on the 7 in. on each side of it, for its length of 12 ft., so the total area of flooring to be supported is $12 \times \frac{14}{12} =$ 14 ft. super.

As the assumed loading is 40 lb. per ft. super, joist B must be strong enough to carry safely $14 \times 40 = 560$ lb. superimposed load.

The dead load must be added to the superimposed load. Assuming the flooring to be $1\frac{1}{4}$ in. thick, the amount of timber flooring to be carried by joist B is:

$$12 \times \frac{14}{12} \times \frac{1\frac{1}{4}}{12} = 1\frac{1}{2} \text{ cu. ft.}$$

The depth of joist is not yet known, but assuming for the moment that it will be 8 in.

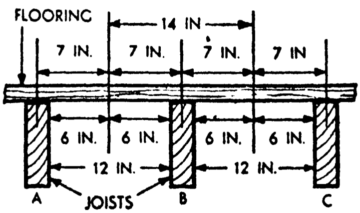


Fig. 20. Typical example of the various dimensions which are involved in calculating the superimposed load for an ordinary timber floor.

deep, then it will contain $12 \times \frac{2}{12} \times \frac{8}{12} = 1\frac{1}{9}$ cu. ft.

Joist and flooring therefore contain a total of $2\frac{5}{6}$ ft. cube, or, say, 3 ft. cube. Taking the weight of timber as 40 lb. per ft. cube, the weight is 120 lb. The plaster and lathing may be taken at 8 lb. per ft. super, and as there are 14 ft. sup. of ceiling, the weight will be 112 lb.

The joist, in this example, must be able safely to carry 560 lb. superimposed load, and 232 lb. dead load; a total of 792 lb. or approximately 7 cwts. What size must the joist be?

A simple formula for wood beams is $W = \frac{Cbd^2}{L}$, where $W =$ breaking weight in cwts., when placed over centre of beam, $C =$ a constant, depending on the variety of timber, and ranging from 2·5 for Oregon pine to 4·5 for English oak, $b =$ breadth of joist in inches, $d =$ depth of joist in inches, $L =$ length of joist in feet—that is, its effective span.

Using a factor of safety of 6, and remembering that a safe distributed load is double the safe central load, the formula may be written shortly as follows:

Safe central point load:

$$W = \frac{Cbd^2}{L \times 6}.$$

Safe distributed load:

$$W = \frac{Cbd^2}{L \times 3}.$$

In the example under consideration, the distributed load is 7 cwts.; the length $12\frac{1}{3}$ ft.; and C may be taken at $2\frac{1}{2}$ for a low-grade timber.

For comparison with the L.C.C. table, given on page 90, the actual breadth of a joist must be taken, and not its nominal breadth. Assuming that a nominal 2 in. joist is to be used, the actual breadth will be $1\frac{7}{8}$ in.

Applying the formula:

$$7 = \frac{2{\cdot}5 \times 1{\cdot}9d^2}{12{\cdot}3 \times 3}$$

Whence $d^2 = 55$, in round figures.

Therefore d is approximately $7\frac{1}{2}$ in., but as the L.C.C. regard this as the least actual size permissible, the nearest larger nominal stock size must be taken, which will be 8×2 in.

L.C.C. By-laws

In pursuance of the London Building (Amendment) Act, 1935, the London County Council made by-laws regulating the use of timber in the construction and conversion of buildings, and these by-laws should invariably be consulted.

Dimensions of timbers are to be actual measurements, and not nominal or scant sizes.

Extracts are given below, using the table applying to non-graded timbers, as applied to joists and binders. The L.C.C. take the length of a timber as being its clear span.

Section 3, *Clause* 18 (1). The minimum depth of any such timber for any pre-determined breadth and spacing shall be determined in the following manner:

(*a*) The spacing factor shall be ascertained by dividing the clear spacing by the breadth of the timber.

(*b*) The spacing factor shall be located in the appropriate column of Table IV or Table V,

as the case may be, or, if there be no such spacing factor in the Table, the next higher spacing factor in the Table shall be located. In no case shall the spacing and the breadth be such that the spacing factor exceeds the maximum shown in the Table (Fig. 21).

(*c*) The length of the timber shall be divided by the number in the column headed "l/d" in the Table set opposite the appropriate spacing factor.

The dimension so obtained shall be the minimum depth of such timber permitted under this section of these by-laws.

(2) The maximum clear spacing for any such timber of predetermined dimensions shall be arrived at in the following manner:

(*a*) The length of the timber shall be divided by the depth.

(*b*) The number corresponding with the quotient so obtained under (*a*) shall be located in the column headed "l/d" in Table IV or Table V as the case may be.

(*c*) The breadth of the timber shall be multiplied by the spacing factor set out opposite such number in the appropriate column of the Table. The dimension so obtained shall be the maximum clear spacing permitted under this section of these by-laws.

Taking the example worked out above, and applying Table IV for non-graded timber: length of joist 12 ft.; breadth 1·9 in. actual; spacing 12 in. By Clause (1) the spacing factor is the clear spacing divided by the breadth = 12 divided by 1·9 = 6·3. Looking down column IV (residential floors) the nearest higher figure is $6\frac{1}{2}$ and the l/d figure on the same line is 19. The length of the joist is 144 in. and this divided by 19 gives $7\frac{11}{19}$, actual size. An 8 by 2-in. joist would therefore be employed.

The maximum clear spacing of joists is found from the tables in the following manner. Assume a nominal 9 by 2 in. joist in ungraded timber over a clear span of 14 ft. in a residential floor. The actual size will be 8·9 by 1·9 in. The length of the timber is to be divided by the depth $= \dfrac{14 \times 12}{8{\cdot}9}$ = 18·8. The nearest higher number in the l/d column is 19. On the l/d 19 line, in column IV for residential floors, is the figure $6\frac{1}{2}$.

The clear spacing between the joists must not be greater than the breadth of the joist multiplied by the factor $6\frac{1}{2}$. $1{\cdot}9 \times 6{\cdot}5 = 12{\cdot}4$ in., which is the required maximum clear spacing.

In practice, of course, the ·4 in. would be disregarded, and the joists would be spaced 12 in. apart.

Concrete Pavings

Concrete is frequently used to form paths, garage approaches, pavings and so on. It is desirable to have an impervious paving near the tradesmen's door of a house, as this is where the dustbins are usually kept.

Concrete is a useful material for paths and pavings, although it is somewhat uninteresting in appearance. In an endeavour to break the monotony of a stretch of concrete, it is sometimes screeded and then scored to imitate crazy paving, the scoring being done when the material is just on the point of setting.

SPACING FACTORS

Col. IV, Joists and binders to residential floors; Col. V, Joists, and VI, Binders to offices above entrance floor; Col. VII, Joists, and VIII, Binders to offices on and below entrance floor and to retail shops and garages for private cars of not more than 2½ tons net weight; Col. IX, Joists and binders to corridors and landings; Col. X, Joists, and XI, Binders to workshops and factories and garages for motor vehicles other than private cars of not more than 2½ tons net weight; Col. XII, Joists and binders to warehouses, book stores, stationery stores and the like.

l/d	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)
5	—	—	—	—	—	—	—	—	15
6	—	—	—	—	—	24½	16	20	12
7	45	—	38½	—	25	21	13½	17	10
8	39½	22	33½	20	22	18	12	14½	9
9	34½	19	29½	17½	19	15½	10½	12½	7½
10	27½	15	23½	14	15	12½	8	10	6
11	22½	12½	19	11	12½	10	6½	8	4½
12	19	10	16	9	10	8½	5	6½	3½
13	16	8½	13½	7½	8½	7	4	5½	—
14	13½	7	11½	6½	7	6	3½	—	—
15	11½	6	10	5½	—	5	—	—	—
16	10	5	8½	4½	—	4	—	—	—
17	9	4½	7½	4	—	—	—	—	—
18	7½	—	6½	—	—	—	—	—	—
19	6½	—	—	—	—	—	—	—	—
20	6	—	—	—	—	—	—	—	—
21	5	—	—	—	—	—	—	—	—
22	4	—	—	—	—	—	—	—	—

l/d	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)
5	—	—	—	—	—	—	—	—	16½
6	—	—	—	—	—	27½	19	23½	13½
7	50	—	43	—	—	23	16	20	11½
8	44	24½	37½	22½	24½	20	14	17½	10
9	39	21½	33	19½	21½	18	12	15	8½
10	35	19½	30	17½	19½	16	11	13½	7½
11	31½	17½	27	16	17½	14½	10	12½	7
12	29	16	24½	14½	16	13	9	11	6
13	24½	13½	21	12	13½	11	7½	9½	5
14	21	11½	18	10½	11½	9½	6	8	4
15	18	9½	15½	9	9½	8	5½	6½	3½
16	15½	8½	13½	7½	8½	7	4½	—	—
17	14	7½	11½	6½	7½	6	4	—	—
18	12	6½	10	5½	—	5	—	—	—
19	10	5	8½	4½	—	4	—	—	—
20	8½	4½	7	4	—	—	—	—	—
21	7	—	6	—	—	—	—	—	—
22	6	—	—	—	—	—	—	—	—
23	5	—	—	—	—	—	—	—	—
24	4½	—	—	—	—	—	—	—	—
25	3½	—	—	—	—	—	—	—	—

Fig. 21. Extracts from Table IV (*top*) and Table V (*bottom*) of the L.C.C. By-Laws regulating the use of timber in the Construction and Conversion of Buildings. The figures in Table IV refer to spacing in relation to dimensions of non-graded timbers supported at both ends. The figures in Table V refer to spacing in relation to dimensions of grade 1200 lb. f. timbers supported at both ends. From these tables minimum depth or maximum clear spacing can be readily found.

CHAPTER 4

JOINERY REPAIR WORK

GENERAL REPAIRS. MECHANICAL DAMAGE. WOOD SHRINKAGE AND SWELLING. FUNGAL GROWTH. PREVENTION OF DECAY. TYPES OF DOORS. HANGING A DOOR. FITTINGS AND FURNITURE. LOCKS AND LATCHES. DEFECTS IN FASTENINGS. DAMAGED PANELS. WINDOW REPAIRS. SASH CORDS. STAIR CONSTRUCTION. WORN AND DAMAGED TREADS. FIXING HANDRAILS. SKIRTING. MATCHING MOULDED MEMBERS. MATERIAL FOR INTERIOR FITTINGS.

REPAIR work to joinery varies to a considerable extent, and may consist of restoring faulty or defective woodwork, or altering existing joinery by the insertion of new work or by the removal of some unwanted portion. The actual amount of repair work to be done on any particular item of joinery is extremely difficult to assess. Much depends upon the general condition of the joinery, as well as on the nature and the extent of the damage which has to be repaired.

Hidden Defects

Old woodwork, especially if covered with several coats of paint, is very deceptive in appearance. Some parts may appear quite sound on the surface, but as soon as a portion is removed or cut away, many serious defects may be exposed. It may be that a temporary patching is the only practicable solution pending a complete renewal of the entire woodwork.

On the other hand, the joinery to be repaired may be of great value, in which case the builder must endeavour to retain as much of the old work as possible. He must carefully match the new work with the old, and closely follow the traditional methods of the original builder in order to preserve the true character of the work.

The jobbing builder should be able to deal with such expert repairs and to offer expert advice to the building owner without creating an impression that he is out to make work merely to increase his profits. In the long run it is always more economical to replace completely a damaged joinery item than to repair it, but the builder should be able to state clearly and concisely his reasons for doing so. A local reputation for a reliable and economical repair is of immense value to a jobbing business, and every effort should be made to establish a good name.

Methods and Materials

In all repair work a sound knowledge of architectural form and material as well as familiarity with the orthodox methods of joinery construction are essential. Joinery constitutes the finishings and fittings which materially add to the comfort, utility and decoration of the building; thus appearance is most important, and neatness should be the main feature of any repair work. Repaired portions should blend with

the existing joinery and should not be conspicuous or unsightly.

For efficient treatment of impaired joinery, the cause of the damage should be carefully considered so that a repetition of the injury can be avoided. Joinery is liable to:

(1) *Mechanical damage* due to defects occurring in the structural fabric of the building, wilful or accidental fracture of some member, or abrasion by excessive wear and tear; (2) *Shrinkage* and *Warping* causing splitting, opening and loosening at the joints, the sagging and binding of movable parts, and (3) *Decay* of the material.

Mechanical damage such as the breakage of members does not present a difficult problem. In general, the procedure is to extract the damaged member, reproduce an identical member and refit it to the old work. Various subterfuges are sometimes employed in jointing the new member so as to avoid dismantling the entire framework of the joinery. No hard and fast rule can be stated for the detailed procedure, but for the general methods of replacing damaged members reference should be made to the subsequent portions of this chapter which deal with the detailed construction of joinery items.

Localised Damage

Fig. 1 shows the general manner of dealing with localised damage. Wood can be readily glued, hence damaged edges or arrises can be replaced by planing off the damaged portion to provide a flat surface on which to joint a new piece of wood. Nails and screws should be used sparingly, and with thin or narrow strips of wood should only be used to hold the wood in position until the glue sets. Generally, the heads of the nails are left protruding to allow for their easy removal.

Clean fractures in the direction of the grain can often be made whole by applying glue and cramping the parts together. In this respect splintered edges can be held in position by strips of paper glued over the surface until the glue is set.

Damage across the grain which does not completely sever the fibres of any member can be repaired by cutting away the damaged portion, and by either inserting a patch or by splicing a new piece of wood to the main body. In both cases careful consideration must be given to the means of fixing the repair piece.

Methods of Patching

Two methods of patching are illustrated in Fig. 1 E to G. Wherever possible the housing for a surface patch should be so arranged that it can be cut with the aid of a saw. The edges of the patch should be slightly splayed, in order to procure a secure fixing. The face should also be splayed, to facilitate fitting and to avoid a joint across the fibres.

Fitting may be accelerated in softwood by inserting saw kerfs in the joints; if the face is splayed, the patch can be pushed forward after each cut is made until the joint makes full contact along its entire length. Patches should be cut large enough to allow for this tightening, the surplus wood being trimmed off when the glue is set.

In a somewhat similar manner a defect on the face of a member may be made good by inserting or inlaying a new piece of wood over the blemish, as shown at Fig. 1 H.

The patch should be first cut to shape with a slight inwards bevel, as shown in the section in Fig. 1, then the exact position it is to occupy should be marked with a scriber or knife before any damaged portion is cut away. If the lines on the damaged portion are simply cut out, the patch will gradually tighten as it is driven in.

Splicing is resorted to where a damaged member is difficult to extract, in which case every precaution should be taken to execute the repairs without weakening the work in any way. To accomplish this, adequate fixing should be provided in the length of the joint itself to give the necessary rigidity. Fig. 2 shows the methods and procedure in splicing members.

Joinery may also become defective due to faults developing in the material itself. Wood will shrink on losing moisture, and swell on absorbing moisture; this movement is always taking place, and it varies in amount according to the changes in humidity of the air in a building. Generally the amount of movement is comparatively small, and takes place with the con-

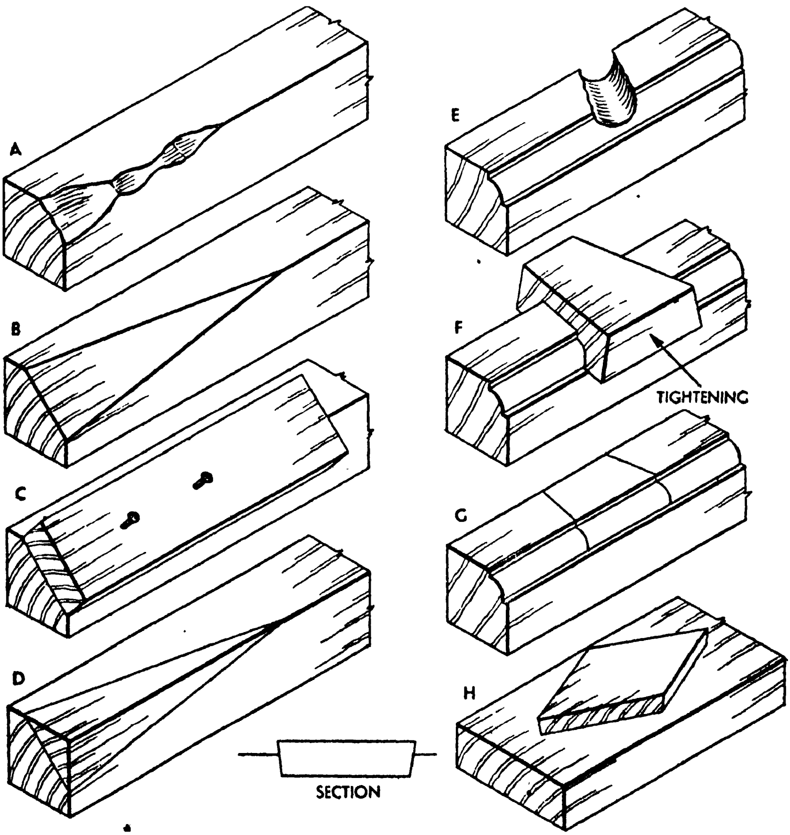


Fig. 1. Treatment of localised damage. *A, B, C* and *D*. Stages in replacing a damaged arris; *E, F* and *G*. Stages in patching; *H*. Inlaying new wood over blemish.

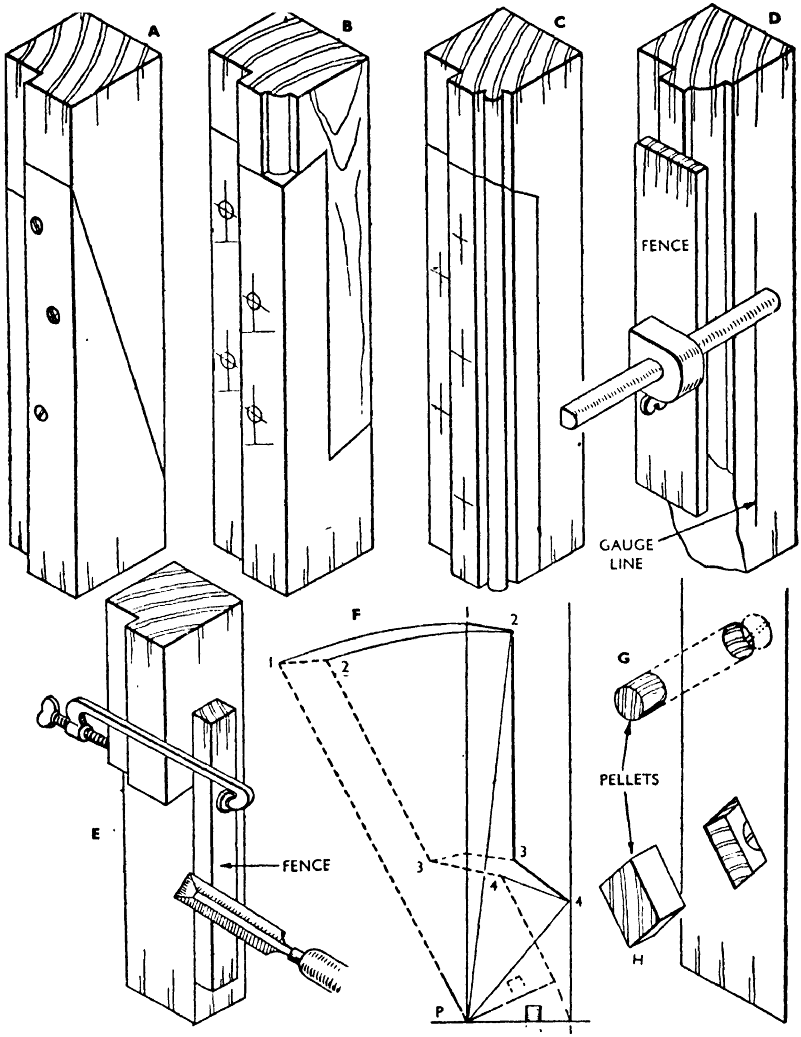


Fig. 2: *A, B* and *C.* Methods of splicing members; *D.* How to mark out the damaged portion; *E.* Ensuring a good joint; *F.* Determining the correct angle of a joint to fit a splicing over a dowel fixing; *G* and *H.* Methods of covering screw heads.

stantly changing seasons of the year.

Precautions against damage by this movement are made by using well-seasoned and dry wood, and by arranging the construction so as to allow for shrinkage. Wide surfaces should be framed in narrow members, and tongued and grooved joints and housings provided to hide the effects of the movement from sight. Cover mouldings and shrinkage fillets should be placed and fixed so that

any movement does not expose an open joint.

Movable framings such as doors and sashes should be so constructed that they will maintain their true shape. This means the careful selection of suitable sizes and the adoption of rigid joints. Parts of joinery subject to hard wear should be replaced with hardwood, and, if necessary, with larger-sized members.

Abnormal Conditions

Often the jobbing builder has to deal with abnormal conditions, such as arise during the installation of new heating systems or in the reconditioning of buildings which have stood empty for some time. The vast changes in humidity which must take place are extremely detrimental to the joinery, and often cause splitting, warping, opening of joints and other disfigurements which can only be corrected by stripping the entire joinery and refitting and adjusting the open joints.

All new wood must be of a moisture content compatible with that of the building it is to occupy. Adequate ventilation must also be provided to all portions of the woodwork, especially at the back of panelling, in order to maintain moisture equilibrium. Further, all exposed surfaces, particularly end grain, should be sealed with a paint, varnish or wax finish to reduce the absorption of moisture by the wood.

Loose joints may be remedied by refitting, gluing and wedging. Further rigidity may be obtained by inserting pegs or wooden pins through the tenons, or by stiffening the joint with metal plates.

A most serious defect in joinery is the decay or rot of the material. Under certain conditions wood will decay, and unless the decay is eradicated at an early stage, it may spread over the entire woodwork of the building. The decay of wood is the immediate concern of the jobbing joiner, not only because a major part of repair work consists of replacing decayed wood, but because cases are known where the source of decay has been introduced into the building by the timber used for the repair.

All decay is due to fungal growth which decomposes the wood substance in order to obtain food. A fungus, of which there are many species, grows from minute spores which germinate on wood which is, or has been, damp. Fine threads called *hyphæ* penetrate the cell walls of the wood, and although in the majority of cases a mass of hyphæ, known as the *mycelium*, is formed on the surface, there can be profuse internal growth, even when the presence of the fungus cannot be detected visually. For this reason, in repairing decayed portions of joinery, it is essential to cut away a considerable amount of the wood surrounding the visible decay.

Testing for Decay

The soundness of wood can be tested by stabbing the surface with the point of a penknife or bradawl ; decayed wood can be pierced without difficulty, while the fibres of sound wood grip the point.

The parts of joinery most vulnerable to decay are those on which moisture collects and cannot readily evaporate. Damage may be caused by the continual leakage of water or by excessive condensation. Window sills, the bottom rails of sashes, window boards, and the lower ends of door posts

are positions most liable to be affected by decay. Other places are behind joinery fixed to walls, especially on outer walls in exposed situations and around water pipes that tend to "sweat".

Decay in external joinery does not often produce a vigorous growth of mycelium and is usually confined to those portions of joinery which are continually damp. The omission of throatings and drips is largely responsible for this condition, and such defects must be remedied. On the other hand, internal joinery, especially unventilated portions which are hidden or built into walls, provide ideal conditions for the growth and development of fungi.

Painted work may appear quite sound on the face, yet be so decayed that any attempt at repair work is futile, and the whole woodwork must be stripped and completely renewed. Fig. 3 illustrates an actual example of hidden decay; it shows the apparent undamaged face of a portion of panelling, the back of which is covered with wood-destroying fungus growth.

Dry wood—that is, wood with a moisture content of less than 20 per cent of the dry weight of the wood—will not decay. Therefore, if moisture can be excluded, or even modified, it will prevent, or at least check, the decay of wood. A further and advisable precaution is to treat all joinery with some preservative. There are many excellent preservatives on the market, which have no objectionable smell and which can be painted over when dry. Some of these preservatives are insoluble in water, and thus can be used for external work.

A satisfactory preservative for internal work may be made by dissolving a quarter pound of commercial sodium fluoride in a gallon of water, and applying the liquid with a brush. In every case

Fig. 3. Typical example of hidden decay in a portion of panelling. From the front view (*left*) the panelling appears to be quite sound but examination of the back (*right*) reveals the extraordinary extent of the decay caused by the wood-destroying fungal growth.

of decayed joinery, the source of the trouble should be traced and dealt with.

The method of approach to any repair work is also governed by the facilities available as well as the quality of the work and the type of damage. It is obviously much more convenient to effect repairs in a well-appointed workshop than in an inhabited building. Machinery, too, is a valuable asset in preparing the material and in shaping the various parts. Full advantage should be taken of these conveniences.

Standard Joinery Items

Many joinery items for domestic work may be purchased ready-made, and the joiner must become acquainted with the various types, standard sizes, and construction as laid down by the British Standard Specifications. Doors in particular can be obtained in stock pattern sizes in many designs.

External doors are obtainable in stock sizes from 2 ft. 6 in. to 3 ft. in width and from 6 ft. 6 in. to 7 ft. 0 in. in height. The sizes most usually held in stock in standard designs are, 2 ft. 8 in. × 6 ft. 8 in. × 2 in.; 2 ft. 10 in. × 6 ft. 10 in. × 2 in.; and 3 ft. 0 in. × 7 ft. 0 in. × 2 in. Internal doors are obtainable in a greater variety of designs in sizes from 2 ft. 0 in. to 2 ft. 10 in. in width, 6 ft. 0 in. to 6 ft. 6 in. in height and from 1¼ in. to 2 in. in thickness. The most commonly used sizes are 2 ft. 0 in. × 6 ft. 0 in. × 1¼ in.; 2 ft. 4 in. × 6 ft. 6 in. × 1½ in.; and 2 ft. 6 in. × 6 ft. 6 in. × 1¼ in., 1½ in., or 1¾ in. thick.

The construction of these doors varies, and is dependent upon the position of the doors, the method employed in their manufacture, and the manner of hanging. Ordinary types of doors may be classed into six main groups, namely:

(1) Ledged or battened doors, suitable for outhouses and temporary work; (2) framed ledged doors, suitable for external work; (3) panelled doors, for internal work, and external work in sheltered positions; (4) half-glass doors, including vestibule and french casements; (5) flush surface doors, which for external use, should have solid panels; (6) small doors for cupboards and sundry fitments.

Ledged doors are constructed of vertical boards, called battens, nailed to horizontal members, called ledges, as shown in Fig. 4 A. Tongued and grooved matching, whose thickness is taken as the thickness of the door, is generally used for the battens. Ledges, of which there are usually three in number, should not be less than 4½ × 1¼ in. nominal size. This type of door has a tendency to drop at the shutting edge, hence diagonal braces, as shown in the diagram, should be inserted between the ledges.

Framed Ledged Doors

Framed ledged doors are much stronger than the type previously described. The battens, or matching, are contained within a skeleton frame constructed of members mortised and tenoned together, as shown in Fig. 4 B. The stiles and top rail are the full thickness of the door, while the middle and bottom rails are of thinner material, to allow the matching to finish flush with the face. These thinner rails are jointed to the stiles with bare-faced tenons in order to maintain the maximum strength of the

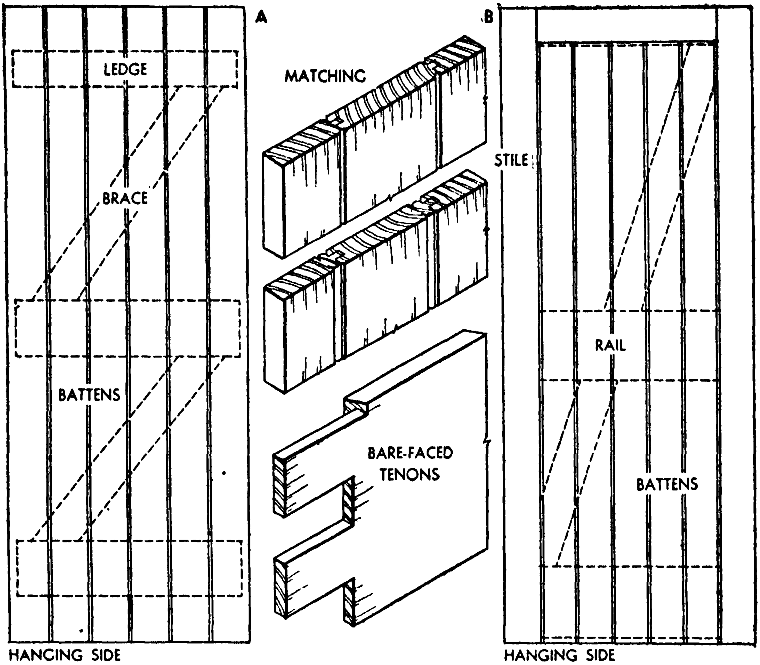


Fig. 4. *A.* Ledged door composed of ledges and matchings; *B.* framed ledged matched door. Note the position of the brace and its relation to the hinged side.

stiles. As in the case of the battened door, diagonal braces should be inserted to prevent the free edge of the door from drooping. Braces should always run upwards from the hinged side of the door.

Panelled doors are made in a variety of arrangements and design, but the principle of construction is common to all arrangements. This consists of providing a rigid frame constructed of stiles, rails and muntins of uniform thickness, and filling the spaces between them with relatively thin panels, which are free to swell and shrink.

The framing members may be connected together with mortise and tenon joints, as illustrated at Fig. 5 A, or the members may be dowelled together, as shown at B. The thickness of each tenon should be approximately one-third the thickness of the door, and the width of each tenon should not exceed five times its thickness. Dowels should be of hardwood, $\frac{5}{8}$ in. diameter $\times$ $4\frac{7}{8}$ in. long, and should be spaced not more than $2\frac{1}{4}$ in. apart. Joints which are dowelled should have a continuous machine scribe or a tongue at the shoulders of the rails.

Panels may be of solid wood or they may be of plyboard; for external doors the plies composing any panel should be resin bonded together to resist the weather. The inner edges of the framing may be moulded on the solid, in which case it is described as a *stuck*

moulding, or the framing may be left square and a separate member, known as a *planted* moulding, pinned to the frame. Both types of finish are shown in the detail of Fig. 5.

Half-glass doors are constructed in a similar manner to panel doors, except that a rebate to receive the glass is formed on the members instead of a groove. Fig. 6 shows two common types of external doors; a door suitable for a back entrance and a door suitable for a front entrance. Note that the rebate for glass is on the outside when putty is used to secure the glass, and on the inside when a glazing bead is used. Fully glazed doors cannot be regarded as in any way burglar proof, as the fastenings can be easily reached by breaking the glass.

Flush surface doors, faced with either veneer or a sheet of ply-board, may be obtained with either a solid or semi-solid core. The former consists of a solid lamin-board, blockboard or framing filled with slab cork, kapok or balsa wood, while the internal construction of the latter varies with the cost from a crude frame-work held together with metal corrugated fasteners to a well-made frame of narrow battens. Typical examples of these types of doors are shown in Fig. 7. Hard-wood lipping or edging strips are fixed to at least one edge of the

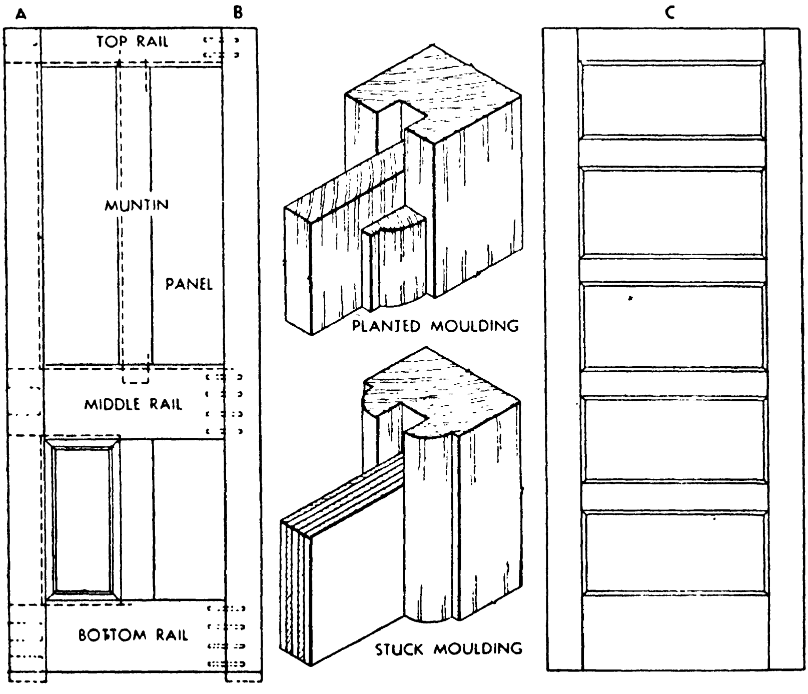


Fig. 5. Internal panelled doors mortised and tenoned as at *A* or dowelled as at *B*; *C*. alternative treatment of panels. The details illustrate how a door may have its moulding planted or moulded in the solid wood.

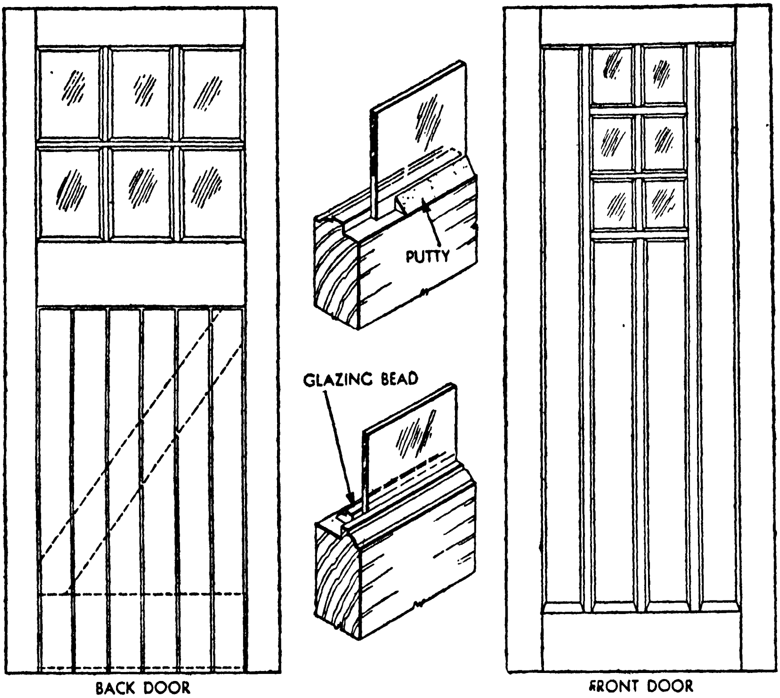


Fig. 6. Two common types of partly glazed external doors. Glass is inserted in a rebate on the outside when putty is used, and on the inside when a glazing fillet is used, because the smaller members are susceptible to decay.

door to protect the edges of the veneer. For a little extra cost, doors may be obtained with one edge shot true and fitted with lock and door furniture. Small doors may be constructed in the manner described for internal doors, or they may be cut from sheets of multi-ply, laminboard or block-board of about ½ in. thickness.

Door Frames

Doors are hinged to solid wood frames and jamb linings of various types. For external doors the solid type is invariably used. These are made from 4 × 2½ in. to 6 × 3 in. material, with a ½-in. rebate on the inner faces to form a stop for the door. Sometimes the rebate is formed by nailing a strip of wood ½ in. thick on the frame, in which case it is known as a *planted stop*.

Door frames are generally built into the wall as the work proceeds. The feet of the jambs are secured to the stone or concrete step by ⅝-in. metal dowels, as shown in Fig. 8, while the top is fixed by encasing the protruding ends of the head, called the horns, in the brickwork. The horns are usually cut to a mitre to bond with the brickwork. Rigidity in the length of the jambs is obtained by fixing hoop-iron cramps to the outside of the frame, as shown in the diagram.

An alternative method is to

drive 6-in. nails partly in the back, so that their heads can be bedded in the cross-joints of the wall. Sometimes pads, plugs or fixing bricks are inserted in the jambs of the wall to receive nails driven through the rebate of the frame after it is built in. Frames should be well braced to keep them square and true during fixing operations by temporary struts nailed in the rebates as shown.

It is wise not to fix hardwood frames until the carcase of the building is complete. Where frames are to be fitted into a reveal it is the usual practice to fix temporary battens on the face to form a screed for a cement mortar backing, as shown in Fig. 9 A. This provides a straight solid face to the frame and obviates the use of unsatisfactory pointing on the outside of the frame.

Fig. 9 also shows a portion of a frame with the usual finishes. Note how the wood lining covers the brickwork jamb, and how the architrave hides the junction between the lining and the plastered wall. The plinth block forms a neat finish to the architrave and skirting board, besides providing solidity at a point subject to hard wear.

Jamb Linings

For internal doors, rebated boards known as *jamb linings* or casings are generally used to form the door surround. These are made from $1\frac{1}{2}$ to 2 in. thick material equal in width to the thickness of the brickwork plus the thickness of the plaster on

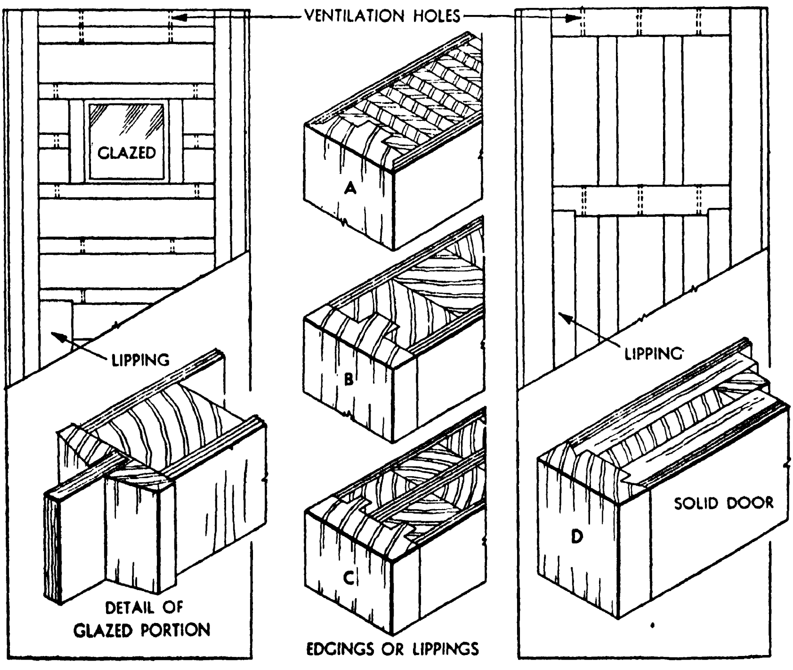


Fig. 7. Flush surface doors. Examples of semi-solid cores. *A, B, C* and *D*. Lippings to solid core doors. The inset shows details of the glazed portion.

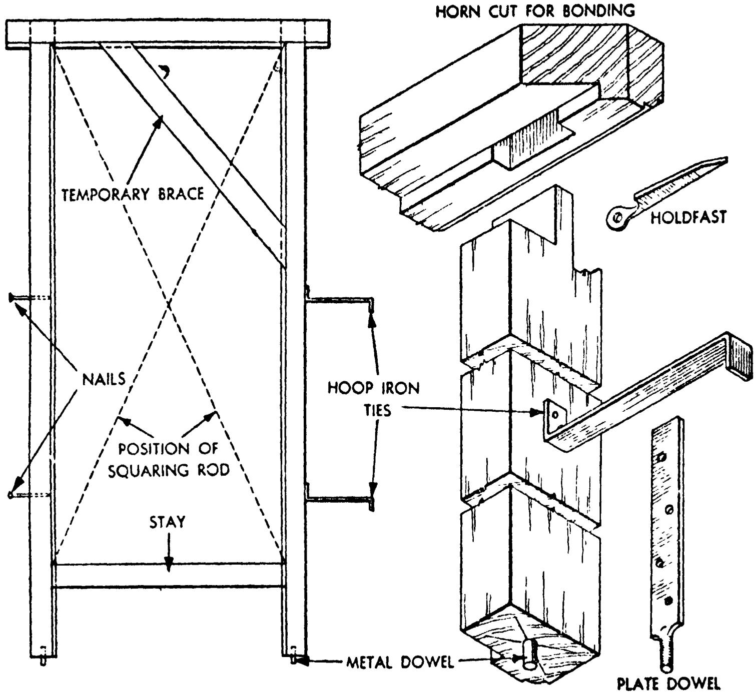


Fig. 8. Solid door frame. The protruding nails or the hoop iron ties are built into the wall as the brickwork is erected. The dotted lines indicate the position of the squaring rod to measure the diagonals and thus check for squareness. Loose door jambs are stiffened by holdfasts or plate dowels.

both sides of the wall. For a half-brick wall of 4½ in., a 5¾ to 6-in. board is used, as shown in Fig. 10 A and B. For a single-brick wall of 9 in. a 10½-in. board would be required, as shown at C. A board of this width is liable to become defective due to shrinkage and curling, and for this reason, it is better to build up wide linings as shown at D and E. Linings may be single rebated, as at B or, to improve the appearance and help in maintaining its shape, may be double rebated, as at C. In cheaper work the door-stop may consist of a separate piece planted on the lining, as at A.

Linings are always fixed after the brickwork is complete, and in good work after the plasterwork is finished. The thinner material obviously requires more fixing in the length of the jamb than does a solid frame. The jambs are housed into the head and nailed either to rough grounds fixed to the wall, or direct to fixing bricks, pads or plugs. It is important that the linings are carefully fixed straight and plumb with the correct margin for plaster on both sides. Packing blocks to take the screws of the hinges and to form a solid backing to the lining at each fixing should be very carefully gauged in order to avoid distortion of the face of the rebate.

Before attempting to fit and hang a door, the size of the opening must be checked. The width should be measured about 1 ft. from the top and bottom, the head tested for square, the rebate checked with a straightedge, and the edges of the jambs sighted to make sure that they are parallel. Although some joiners use a 3-ft. rule for checking the door opening, the general procedure is to measure the width by means of pinch rods.

Correcting Faults

If the door is too short, a strip should be nailed to the bottom edge between the horns of the door. A door too wide should have an equal amount planed off both edges to maintain a uniform appearance. If the door is large enough, the horns on the top and bottom edges are sawn off, and the hanging stile planed until the edge makes a reasonable fit with the jamb lining. During planing operations the door is held in position by the appliance shown in Fig. 11 A. This is merely a length of 4 × 3 in. material with a housing cut in the centre to receive the door edge, the door being held by means of a wedge which can be easily kicked out when the door is being lifted for fitting.

When the hanging edge has been fitted, the door should be placed in the opening and marked for size by running a pencil line along the shutting edge and the top. The edges should then be planed to these marks and then again tried in position. A door

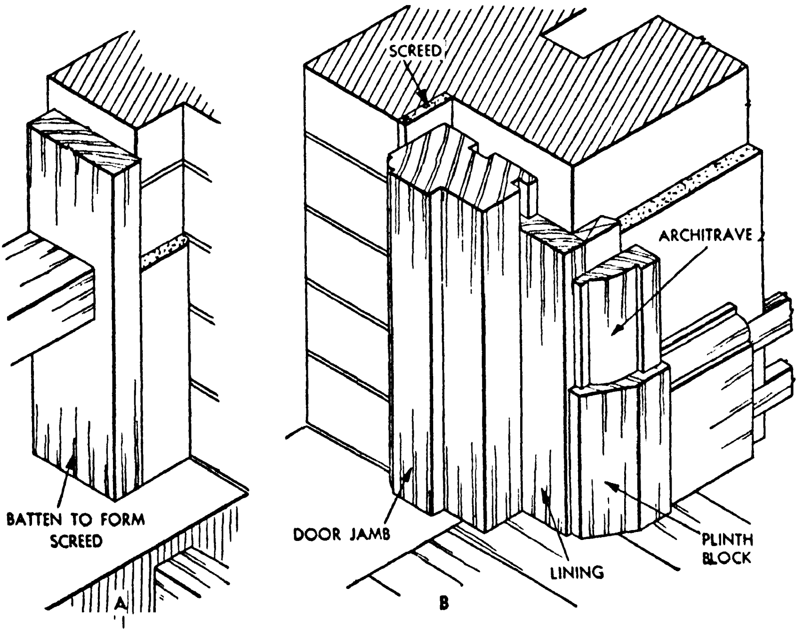


Fig. 9. A. How a straight face is obtained on a brickwork reveal to receive a door frame inserted after the brickwork is complete; B. finish to external door frame.

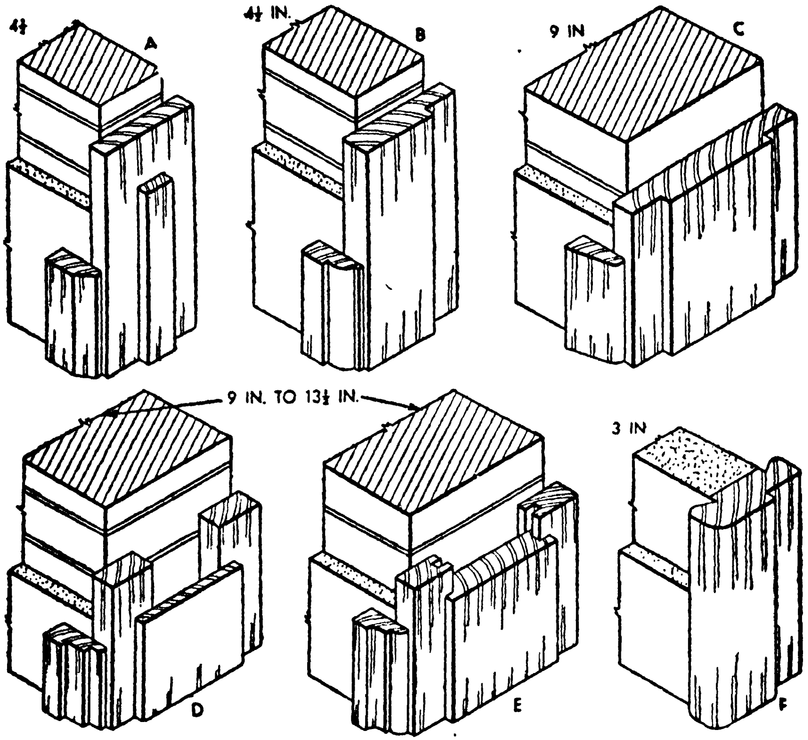


Fig. 10. Thickness of wall decides the type of construction of jamb linings or casings. *A* and *B*. Half-brick wall with lining and planted door stop; *C*. 9 in. wall; *D* and *E*. built-up linings; *F*. solid frame with provision for plaster.

should not fit too tightly; adequate clearance for any possible swelling and for several coats of paint should be provided.

For softwood doors there should be about $\frac{1}{8}$-in. clearance, or the thickness of a penny, on both edges of the door. On both the shutting edge and the hanging edge a slight clearing bevel should be formed, to prevent the door binding in the rebate. For a thick, narrow door the bevel is pronounced, and in such an instance it is better to splay the rebate as well as the door edge.

When the top edge is fitted, the door should be wedged upwards from the bottom and a line parallel with the floor scribed on the door with the dividers. The clearance allowance varies from $\frac{1}{8}$ to $\frac{1}{4}$ in. for external doors to $\frac{1}{2}$ in. for internal doors to allow for lino, carpet or rugs.

A door is usually hung to its frame with a pair of butt hinges placed so that they do not cut into the end grain of the tenons on the rails. This means that the top hinge is about 6 or 7 in. from the top of the door, and the bottom hinge about 11 in. from the bottom. One flap of each hinge should be sunk into the edge of the door, and the other flap similarly sunk into the frame.

Door butts have five joints in the knuckle, and it is important that the flap with three joints is fixed to the frame, so as to take the strain of the door.

Hinges are fitted to the door first. To ensure accurate fitting, they are marked out with a gauge set to the distances shown in Fig. 11. *W* is the width of the flap to the inside edge of the pin, and *T* is the thickness. The housing for the hinge may be cut with a saw and pared out with a chisel, as shown at B; then the hinges screwed to the door so that the flap of the hinge and the screw-heads fit flush with the edge of the door, so as to avoid the possibility of binding.

The door should then be placed in position with the hinges open, and packed up with a chisel or wedges until the correct amount of clearance shows all round. The positions of the hinges and the thickness of the knuckles should then be clearly marked on the edge of the frame with a scriber or pen-knife, as shown at Fig. 11 C. When the housings are cut in the jamb, the door should be held at right-angles to the jamb and wedged until the correct position is obtained with the flaps in their recesses. One screw should then be inserted into each flap until the door has been tested by closing.

This precaution is necessary

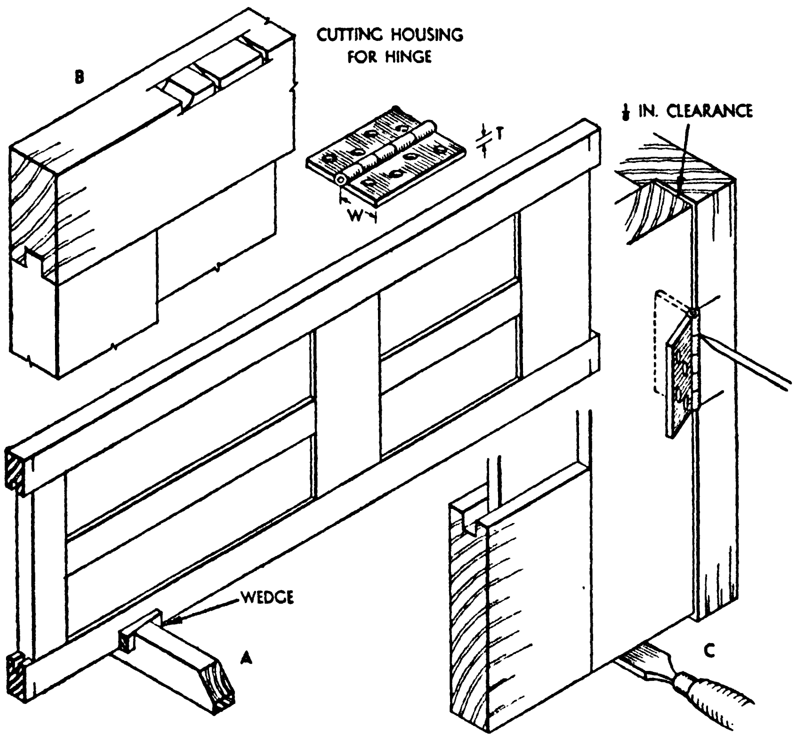


Fig. 11. Hanging a door. A. Cradle to hold door during planing operations; *B.* method of cutting recesses for hinge. *W* is width to inside edge of pin, and *T* is the thickness of flap; *C.* how depth of recess on edge of jamb is marked.

because the door may have to be adjusted by further sinking of the hinges, or even packing them out, and new screw holes made to hold the door in the new position. When the door fits the rebate properly and swings without rubbing or fouling the jamb, all screws should be inserted and the door furniture fixed.

Doors purchased from the manufacturers already fitted with locks, and flush surface doors with a veneered edge, must of course be fitted by planing only the hanging edge and the top and bottom edges. Usually the door furniture is packed separately, to avoid damage in transit; keys and striking plates are often securely stapled to the edge of the top rail of the door. For odd doors it is a great saving in labour and cost to have locks fitted before delivery, especially if mortise locks are required.

Fittings and Furniture

Door fittings and furniture include all the ironmongery necessary to hang the door and to secure it in position when closed. Hinges are obtainable in three grades of light, medium and heavy, in a variety of shapes and sizes. For thin doors, such as a ledged batten door, a pair of tee hinges are used. These are screwed on the face of the door with either countersunk or round-headed screws.

Scotch tee hinges are obtainable with a black japanned or galvanised finish in sizes from 10 to 24 in. in even inches of length, the length being measured to the centre of the knuckle. A better quality hinge is the wrought-iron cross garnet, while for exposed positions the water-joint hinge is less likely to rust at the pivot. Tee hinges should extend about two-thirds across the face of the door supported.

For framed doors, butt hinges are used. These are obtainable in cast iron, wrought iron, pressed steel and brass, in ½-in. sizes from 1 to 6 in. in length. Where a door is required to swing over a thick floor covering or an irregular floor, rising butts may be used. These may be in the form of a skew hinge with a helical knuckle, which causes the door to rise upon being opened, or the pin may have a square spiral thread to give the lifting action.

To enable a door to open well back over an architrave or other projection, the pivot of the hinge must protrude from the edge of the door. Special hinges, known as parliament hinges, are used for this purpose, and have projecting knuckles. They allow a door to fold back over a reveal.

Double-action spring hinges are used for doors which are required to open both ways and to close automatically. They consist of three flaps with helical springs within the barrel joints. Small holes are provided at the top of the barrel to enable the springs to be regulated and released during fixing. Generally, the bottom hinge is a blank—that is, without springs. Heavier doors are hinged with pivots fitted in the ends of the door and controlled by a box spring fitted flush with the floor.

The fastenings to a door may consist of a lock, a latch or a two-bolt lock in which a latch and a lock are contained in the same case. A latch differs from a lock in that it is self-closing and is released by turning the door knob, while a lock requires a key to shoot the bolt. The mechanism of locks consists of arrangements which

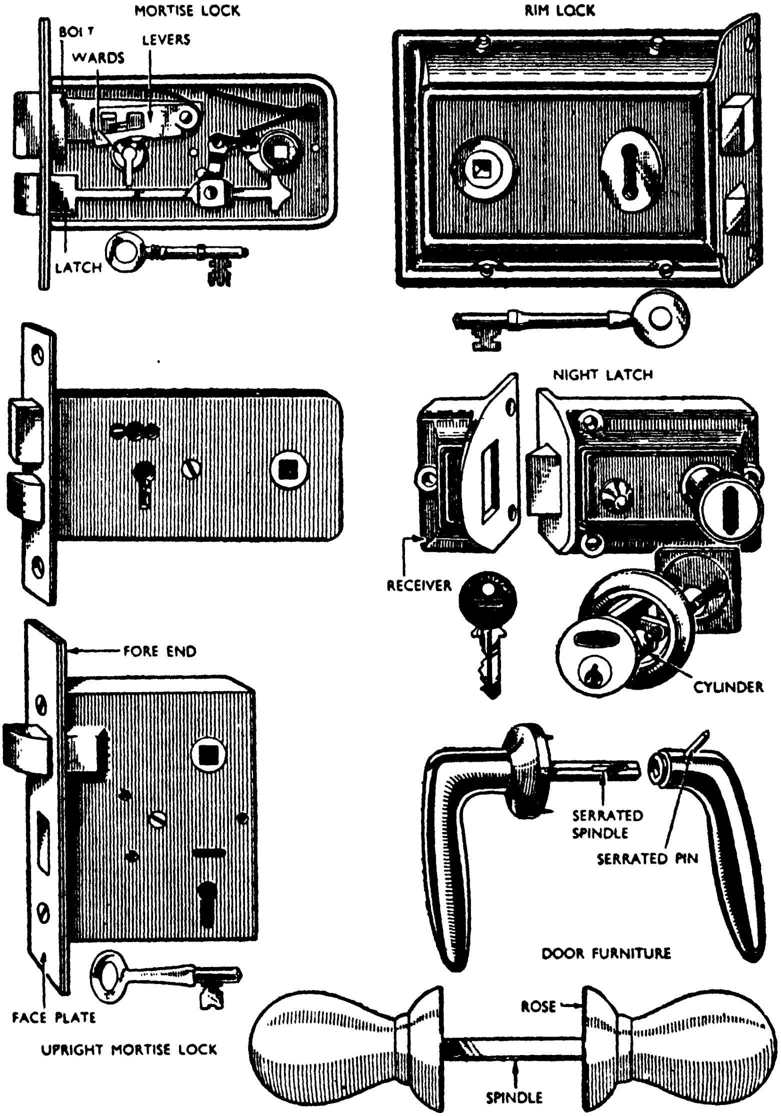


Fig. 12. Various types of door locks and latches which are in common use.

prevent the bolt being pushed in or out without the proper key. It may consist of wards over which the key must pass and a tumbler to shoot the bolt, or of a series of levers which must be raised to the correct height to shoot the bolt, or of pin tumblers within a revolving cylinder.

The cases which contain the

mechanism are of two types: those which are screwed on the face of the door, known as rim locks and rim latches; and those which are recessed or mortised into the edge of the door, known as mortise locks and mortise latches. Both types are illustrated in Fig. 12. Latch bolts in mortise locks and in some rim latches are reversible and can be altered as occasion demands. A mortise latch with a reversible bolt can be adjusted to suit the hand of the door, but a rim latch, even with a reversible bolt, must be of the correct hand. The hand of a rim latch is determined by standing outside the door with the latch inside; if the bolts project to the left, it is a left-hand latch, if to the right, a right-hand latch (Fig. 13).

To fix a rim latch or lock on a door, the case should be held in the required position, the shape of the fore-end marked on the door edge, and a recess made so that the fore-end fits flush with the edge of the door. Holes should then be bored for the keyhole and the spindle with $\frac{3}{8}$-in. and $\frac{5}{8}$-in. twist bits respectively. To avoid splintering the wood, the holes should be drilled until the point of the bit protrudes from the opposite side, then the bit should be removed and the hole completed from the opposite side.

The keyhole should then be cut to the required shape with either a small chisel or a keyhole saw, and the case screwed on the door with the key and spindle for the door knobs in position. The receiver or box staple should then be fixed to the door frame with sufficient clearance to allow the latch to work freely and without undue rattling. This often means cutting through the architrave which surrounds the door opening.

Fixing a mortise lock to a door is a more difficult operation, unless the mortise has been cut before-hand. The door is wedged open about half-way, the position of the keyhole marked, and the edge of the door gauged for a $\frac{9}{16}$ or $\frac{5}{8}$-in. mortise, according to the thickness of the lock. A series of

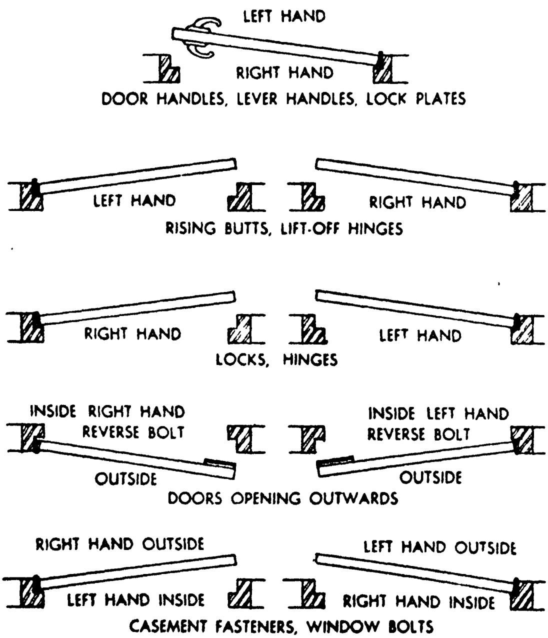


Fig. 13. Method of determining the correct hand of a fitting when ordering hardware from the suppliers.

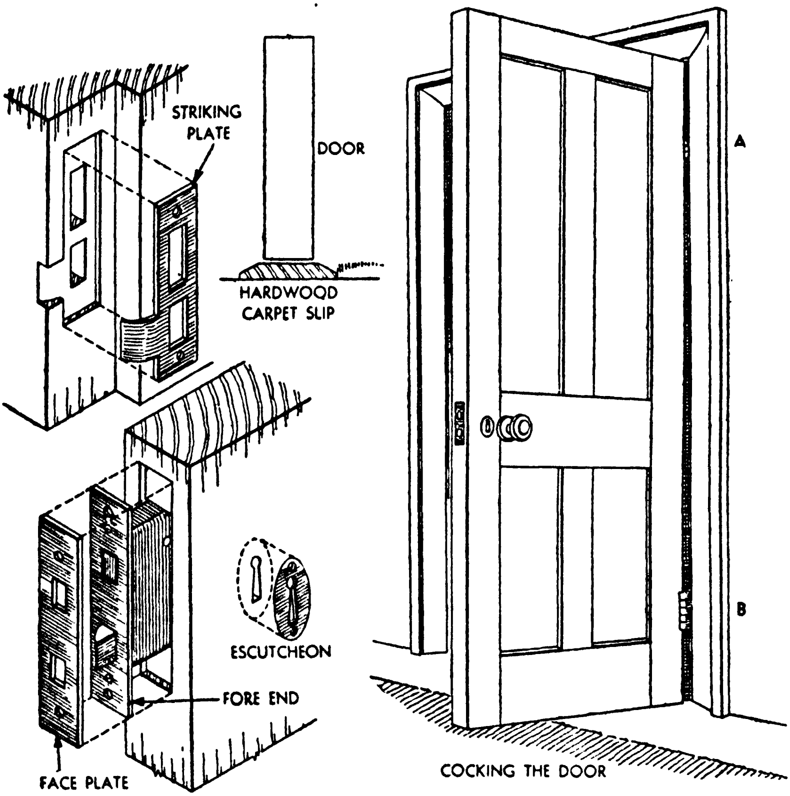


Fig. 14. The hinge at *B* protrudes more than the hinge at *A*, thus throwing the edge of the door upwards on opening. The details illustrated on the left hand side show the fitting of a mortise lock and striking plate.

holes should then be bored within the gauge lines and the waste wood chopped out with a swan-necked chisel and wide paring chisel. The mortise must be parallel with the face of the door and be cleanly cut, otherwise the fore-end of the lock will not be in alignment with the edge of the door, and there will not be sufficient material to hold the fixing screws of the door furniture.

The lock should then be inserted, the fore-end marked, and the recess cut, as shown in Fig. 14, so that the face plate will fit flush with the edge of the door. Holes for key and door spindle should be marked on both sides of the door and cut from both sides; then the lock is inserted and secured with screws through the fore-end. After the key and spindle have been tested for smooth working in the lock, the face-plate should be screwed into position and the striking-plate fixed.

Every care should be taken in fixing the striking-plate, otherwise the latch will not engage properly. The correct position may be determined by partly closing the door

and marking the positions of the bolts where they strike the rebate. The plate should then be held in position and its outline scribed on the door jamb.

Sometimes the positions of the bolts are checked by rubbing the ends of the bolts with chalk or black oil from the oilstone, closing the door and then shooting the bolts against the rebate. Separate holes should be cut for the latch and the bolt, slightly longer than the bolts, to allow for the door to droop. Before fixing the plate, the protruding lip should be bent away from the door to allow the bevelled latch to slide more easily in closing.

Door furniture includes the knobs or handles and the escutcheons to cover the keyholes. Door knobs may be attached to their spindles in a variety of ways. A knob may be held by its rose and be free to swivel on it, while the spindle which operates the latch is merely fitted into the knob; or the spindle may be drilled to receive a grub or fixing screw inserted through the neck of the knob.

Adjustment of Spindle

Adjustment of the spindle to suit the thickness of the door may be made either by having a series of holes on both ends at varying distances apart, or by using a spindle which is threaded down a portion of its length and secured by a grub screw. When a knob is to be fixed to its spindle, the rose should be screwed to the door before the knob is attached.

A night latch is self-locking and is operated by a key from the outside and by a knob inside. This is generally of the pin-tumbler type, of which there are many patent types on the market. Manufacturers invariably include instructions for fixing with each lock. This type of lock is so popular that a 1½-in. brace bit which is used for fitting it has become an essential tool for the joiner fixer.

Wards and Springs

The wards and springs are the most likely parts of a lock to need attention, which usually consists of cleaning and oiling, with occasionally replacing a broken spring. Pin tumblers in a cylinder latch should not be oiled, but should be lubricated with black-lead; nor should any attempt be made at replacing broken springs, because of the complexity of the mechanism.

A common fault with door fastenings is the displacement of the striking plate causing the latch to spring open. This defect is generally caused by the door drooping, and may be remedied by filing the mortise holes of the plate to allow for the lower position of the bolts, or by refitting the plate.

Sometimes a door sticks at its closing edge. This may be due to many coats of paint, settlement of the wall containing the door frame, swelling of the wood, or the screws in the hinges working loose. Except in the last instance, the door should be taken off its hinges and refitted by planing the hinged edge and re-cutting the recesses for the hinges. This avoids defacing the edge of the door which is exposed to view, and avoids refitting the lock and door furniture. Loose screws should be tightened or replaced with larger size screws. For larger screws the countersinks must be enlarged to prevent the heads binding. Looseness at the hinges can be readily ascertained

by lifting the door at the handle, when any movement denotes slackness.

Hinge binding (Fig. 15 A) is the most common trouble with a door, and is often responsible for loose hinges and worn latch bolts. Generally the hinge must be packed out or adjusted to give the necessary clearance on the hinged edge. In new joinery the trouble can often be traced to the shrinkage of the stiles, which leaves the ends of the tenons on the rails protruding, as shown in Fig. 15 B.

The bottom edge of a door is often a source of trouble. It may scrape over an uneven floor or thick covering, such as a carpet, but if it is planed to clear the obstruction it will leave a gap which creates a draught. To overcome this difficulty, the door may be made to rise as it opens. This may be accomplished either by fixing rising butts or by cocking the door. Rising butts usually necessitate the top edge of the door being bevelled, and unless the rebate on the frame is also bevelled, an aperture likely to cause a draught is formed.

Clearance by cocking the door is obtained by allowing the bottom hinge to protrude more than the top hinge. This throws the edge of the door upwards on opening to clear the floor, as shown in Fig. 14. Both these methods tend to make the door self-closing. A better way to ensure that a door clears the floor covering and yet maintains a minimum space at the bottom when closed, is to fix a hardwood carpet slip across the threshold, as illustrated in Fig. 14.

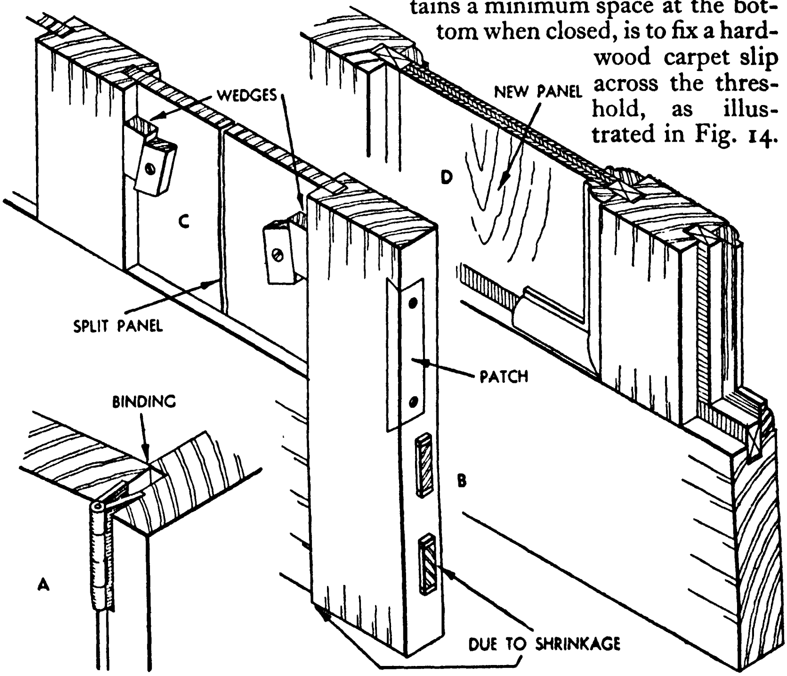


Fig. 15. Binding doors and damaged panels. A shows binding on lining. Hinge binding may also be due to the stile shrinking which leaves tenon ends protruding as at *B*; *C*. how a split panel can be cramped; and *D*, how it can be replaced.

At the bottom of external doors the difficulty is to keep out driving rain and draughts. A hardwood threshold, with galvanised water bar and properly fitted weather moulding, provides the most satisfactory arrangement. Fig. 16 shows several types of weather boards and the methods of fixing; note that the ends are splayed to give the necessary clearance when the door is opened.

Ill-fitting doors should be corrected by gluing strips on both edges, and refitting. Door stiles damaged by the hinges being torn off should be patched by inlaying new material, or by cutting down the length of the stile and gluing and screwing a new piece along its edge. Rails whose tenons are broken near the shoulder should have dowels inserted through the stile into the rail, or should be fitted with a false tenon pegged through the rail, as shown in Fig. 16.

Occasionally it may be necessary to replace a damaged panel. In many cases it may not be advisable to take the door to pieces because of the liability of damage to the stile and rails, particularly if the shoulders of the rails are well glued. If the door is moulded on the solid, the moulding on one face should be cut away, a new panel inserted, and a moulding to match the original member should be carefully fixed round the panel.

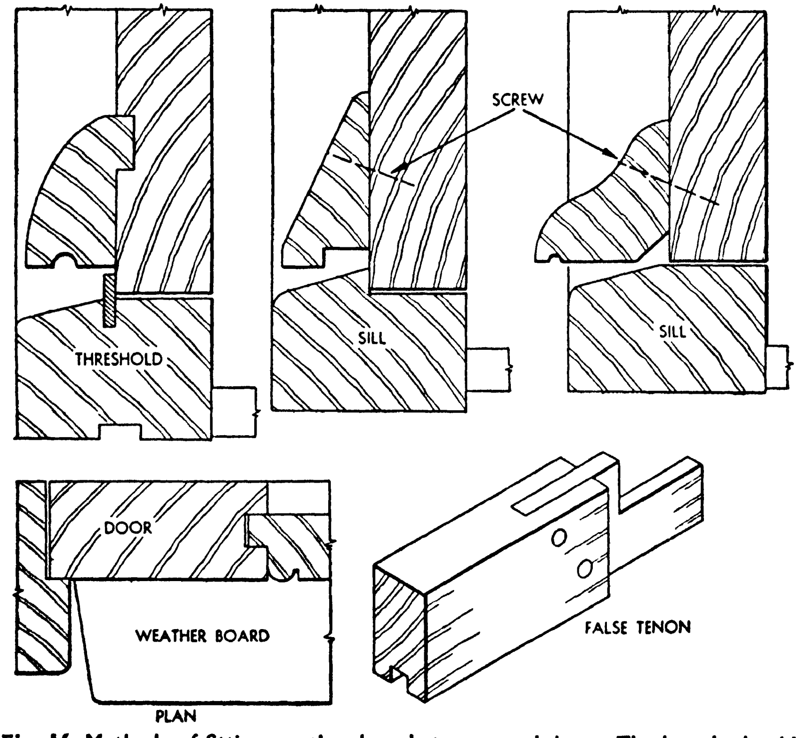


Fig. 16. Methods of fitting weather boards to external doors. The boards should be splayed at one end as shown in the plan so as to avoid fouling the door jamb

Doors with planted mouldings require different treatment. The moulding should be carefully removed, the damaged panel cut out by boring a series of holes and then cutting across the panel with a compass saw. Strips of wood should then be inserted in the panel grooves, as shown in Fig. 15 D. These strips should be of a width equal to the depth of the groove, plus half the width of the planted moulding, so that when fitted in the panel groove they form a rebate with the planted moulding and a groove when the detached moulding is replaced.

To obtain additional rigidity and to facilitate fixing, the sides of the new panel should be rebated and glued to the vertical strips. When the glue is dry, the joints should be cleaned up and the planted mouldings replaced.

Apart from mechanical damage, a general cause of solid panels splitting is due to improper nailing of the planted mouldings. Nails which are inserted through a panel prevent it from shrinking in the plough grooves, and consequently produce a split. A split in a panel may be repaired either by gluing and cramping the parts together; or, if the arrises are damaged, by inserting a dovetailed slip between the pieces.

To cramp a panel in its frame, the mouldings should be removed and a series of small blocks screwed to the panel as shown in Fig. 15 C. By carefully levering with a chisel and tapping wedges between the blocks and the frame, the parts of the panel can be forced together and the joint held until the glue is set. When the glue is set the surfaces of the joint should be carefully smoothed with a block plane, scraper and glasspaper.

Loose door frames may be stiffened by holdfasts and plate dowels (shown in Fig. 8) fixed to the wall and the frame, while the decayed ends of the posts should be spliced or scarfed, as shown in Fig. 2. The illustration at F in this diagram shows how to determine the correct angle of a joint to fit a splicing over a dowel fixing. Points 3 and 4 are on a line perpendicular, that is, at right angles or square to, the line 4 *P*, and points 1 and 2 are perpendicular to the line 2 *P*. This enables the splicing to pivot about point *P*, so that the dowel fits into the original hole in the stone or concrete step.

Window Repairs

Repair work in connection with windows chiefly consists of making good decayed portions, and of overhauling the opening parts by replacing worn or broken members. In this respect attention must be given to maintaining a weather-tight construction, yet providing for easy manipulation of the movable parts for ventilation and cleaning purposes.

The size of a window is determined by the relation of its area and the area of the floor in the room it lights. By-laws require that the glass area of windows shall be at least one-tenth of the area of the floor of the room, and that half the glass area be made to open for ventilation purposes. The dimensions of a window are taken from the net brickwork opening, from the top of the sill to the underside of the arch or lintel and horizontally between the reveals. These sizes differ from the overall (O/A) size, as shown in Fig. 19. Mass-produced windows are obtainable in many standard

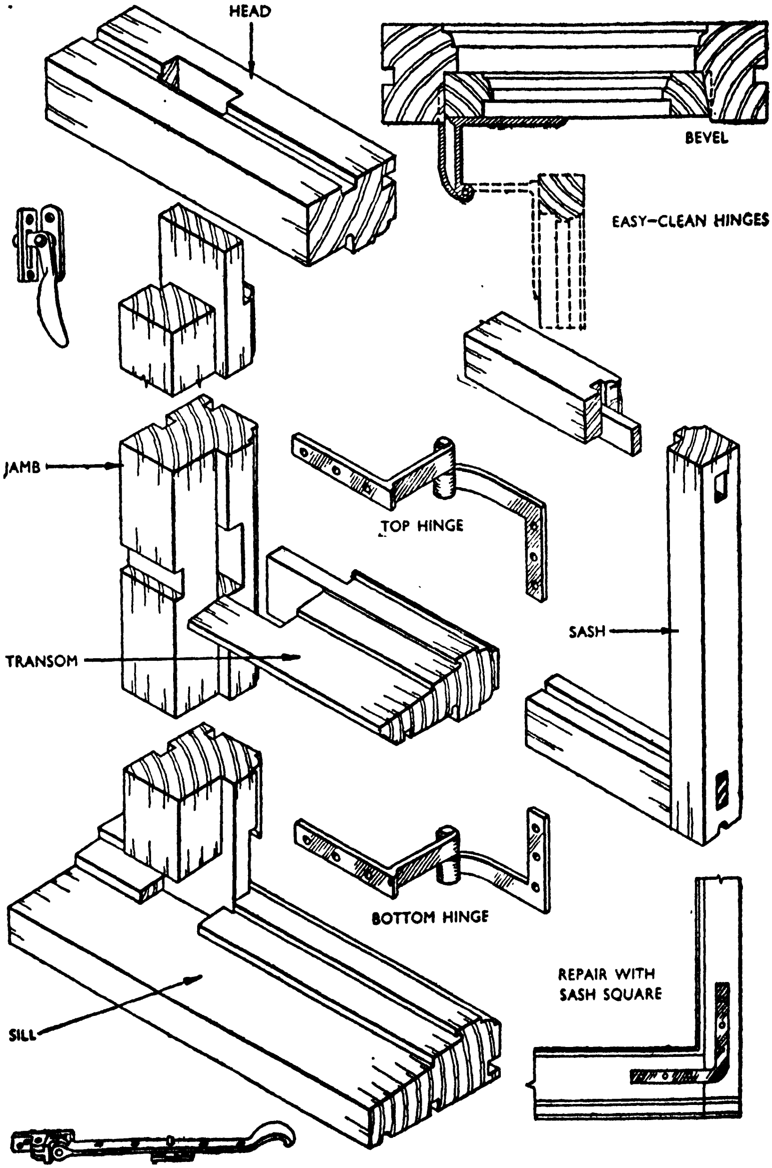


Fig. 17. Construction of casement window frame and sashes. Damaged sashes are repaired with a "sash square" sunk flush with the surface of the sash. Easy-clean hinges should be fitted to the frame before they are fixed to the face of the sash. These enable the window to be cleaned easily from the inside, as they provide ample space between the hanging stile and the frame.

sizes which are based on the sight size of the glass.

The term window describes the complete construction, including the sashes which carry the glazing and the frame which supports the sashes. Sashes are light framings of wood or of metal from $1\frac{1}{4}$ to $2\frac{1}{2}$ in. in thickness, according to their size and purpose. Wooden sashes consist of rebated stiles and rails with or without intermediate glazing bars. Frames are of two main types: solid frames, known as casement windows, and built-up frames, known as boxed or cased frames.

Casement windows of wood, metal or metal in a wood frame, are further described by the treatment of the sashes. These may be hinged at the top, side or bottom, be centre hung on pivots, arranged to slide horizontally, or to fold.

A casement window frame consists of two horizontal members called head and sill respectively, with two jambs tenoned into them; the joints between these members are shown in Fig. 17. The width

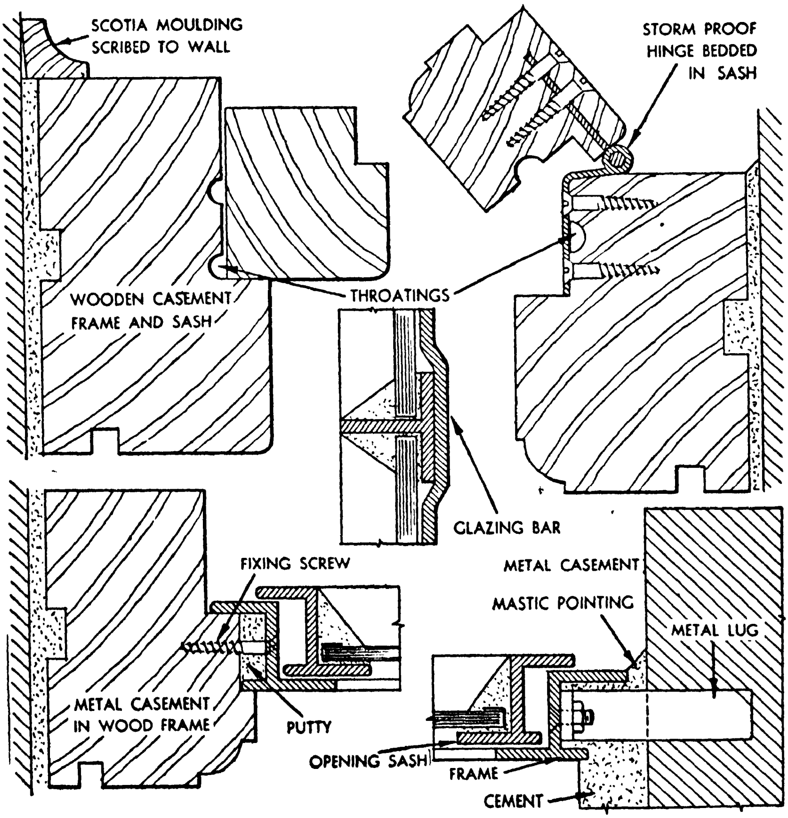


Fig. 18. Half full-size sections of jamb to casement windows. In repair work the joint between the frame and the walls must be carefully sealed either by pointing with mastic or by scribing a moulding to the wall.

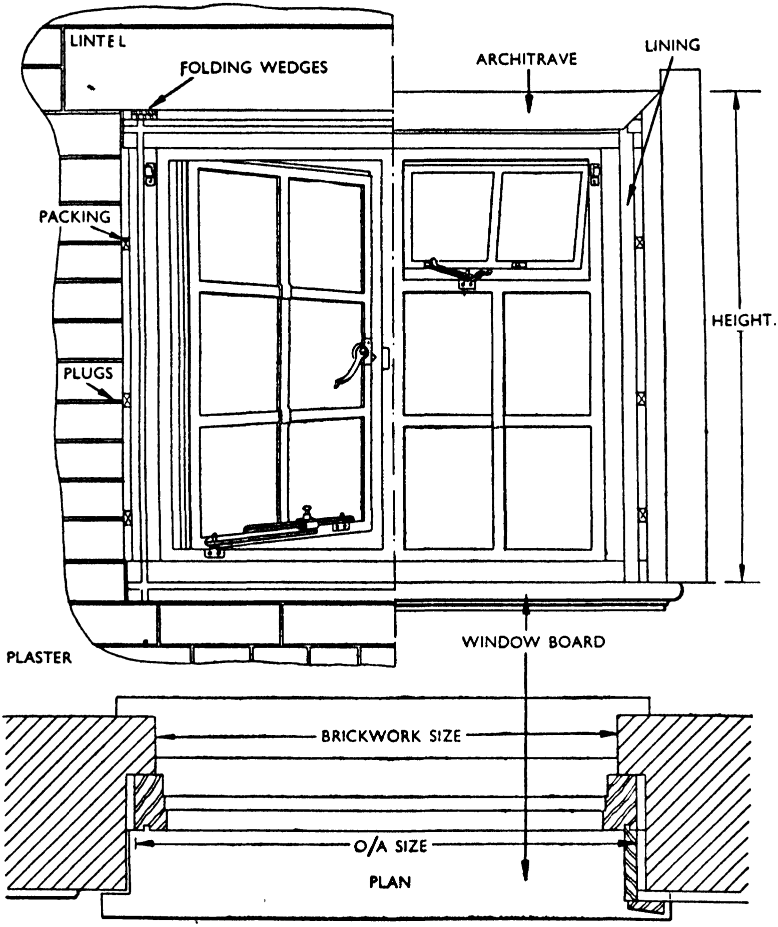


Fig. 19. Method of fixing casement window in existing brickwork opening. (*Left*) Folding wedges at head and plugs in wall for frame and linings. Note how the window board is fitted round the brickwork. (*Right*) How to fit the architrave.

may be divided into "lights" by vertical members called mullions, and the height divided by a horizontal member called a transom; or by two sashes rebated together, known as a split transom. Sashes may be hinged to the frame to open either outwards or inwards, the former being the more weather-resisting.

Repair work to casement windows generally consists of easing jammed sashes, or of patching the sill and the bottom rail; or of re-hinging the sashes due to damage caused by the wind blowing them open against the window jamb.

Jammed sashes may be due to the sash drooping, the wood swelling or the hinges becoming distorted owing to the sash binding.

After the necessary adjustment has been made by planing the edges of the sashes, it is essential that the newly planed edges are treated with a coat of paint, to protect the wood from the weather. For this same reason joints to all external patching or splicing should be well coated with a mixture of white lead, and the nails or screws used for fixing sunk below the surface, and their heads covered with putty.

Decayed Sash Rails

Bottom rails of sashes are particularly vulnerable to decay if the putty fillet on the glazing becomes loose, or if the paint blisters and is allowed to expose the wood for any length of time. These exposed irregularities form a catchment for rain, which easily penetrates into the wood. In many cases water is driven into the joint between the sill and the bottom rail of the sash; it is partially absorbed by the rail, cannot dry out freely, and tends to cause rot. Broken tenons or weak joints should be strengthened with sash squares, as shown in Fig. 17. These repair plates should be sunk flush with the surface of the sash, so as to be inconspicuous. Strained hinges should be straightened and oiled or replaced, and the damaged fabric repaired in the manner previously described for doors.

Windows must be capable of being easily cleaned, and for this purpose special hinges are often required to be fitted to an existing sash. Easy-clean hinges, as shown in Fig. 17, provide ample space between the hanging stile and the frame when the sash is open to enable the outside of the window to be cleaned without difficulty from the inside of the building.

Because of the altered position of the pivot, a bevel is necessary on the shutting edge of the stile. The angle of this bevel varies according to the width of the sash, in that the narrower the sash the greater is the bevel required. For a sash of about 18 in. wide a bevel of about $\frac{5}{16}$ in. is required, but for a sash 3 ft. wide a $\frac{1}{8}$-in. bevel is sufficient. When adequate clearance has been made, the hinges should be housed into and fixed to the frame before they are fixed to the face of the sash. Easy-clean hinges of this type should be obtained in pairs of the correct hand.

In overhauling windows the joint between the wood frame and the brickwork should be cxamined and, if necessary, repointed with mastic, or covered by scribing a moulding to the wall, as shown in the section Fig. 18.

Throatings and Wind Checks

Modern casement windows are made with a multitude of grooves called throatings and wind checks, on the edges of the sashes and on the faces of the rebates, to prevent driving rain penetrating inside the frame. This weather-resisting device does not rely upon the traditional close fitting of the sashes; instead, spaces are left between the sash and its frame. The sashes therefore do not stick, and only require easing on rare occasions.

Generally the edges of the sashes are rebated over the outside face of the frame to shield the joint. This rebated lipping necessitates the use of special stormproof hinges, as shown in section in Fig. 18, which are mortised into the edge of the sash. Hinges of this type require careful adjustment when strained, but as they are

generally made of malleable metal, they can be easily hammered back to their original shape.

Fastenings to casement windows are fairly simple to fix. To hold the sash closed, a cockspur fastener is screwed to the face of the sash so that its tongue engages a mortise plate fitted flush with the surface of the frame. To fasten the sash in an open position, casement stays are used. These may be in the form of a hinged bar with holes at intervals along its length to fit over a pin plate screwed on the sill, or of a sliding bar secured with an adjustable thumbscrew. Casement fittings are generally merely screwed to the face of the sash, and do not require much cutting.

Metal Windows

Metal windows are obtainable in many standard sizes and in many designs, with the opening sashes complete with all fittings and fastenings. The frames are usually built into the wall as the work proceeds, and are secured there by protruding metal lugs attached to the frame, as shown in section in Fig. 18. As a general rule, the frame is erected when the wall has been built to the sill level. Every care should be taken that the frame is level and the jambs plumb in both directions. This should be done by packing the ends of the frame, testing for level and plumb, and then strutting the frame to keep it rigid until it is firmly encased by the brickwork. The packing of the sill should be sufficient to allow a brick or tile sill to be built up when the carcase of the building is complete.

During the erection of the wall, the flange of the frame should be carefully filled with cement, to ensure a solid connection to the wall, and on completion the external joint between the frame and the wall should be pointed with mastic to seal any possible crevice.

Inserting a metal window into a prepared opening is a more exacting task, because the width of the framing is only $\frac{3}{4}$ in. on the face, and this small size does not allow much latitude when offering the frame into position. Special attention must also be given to the bedding and pointing of the frame, in order to produce a sound attachment to the wall.

A metal window within a wood frame or surround provides a more satisfactory construction, and gives greater rigidity, in addition to being easier to fix and simpler to finish. The wood frame should be constructed in the usual manner, except that the inner faces should be rebated to fit the metal frame, as shown in Fig. 18. To ensure a water-tight joint between the two frames, the metal frame should be well bedded in oil putty or mastic. In this operation G-cramps should be used to pull the frames together and hold them in position until the fixing screws are inserted. Fixing screws are inserted through the holes provided for attaching the metal lugs.

To fix a casement window into an existing opening, the sizes should be carefully checked and compared with those of the frame. In this respect it is important to note whether the brickwork jambs are square or recessed, because the latter arrangement affects the overall sizes of the window. As shown in Fig. 19 a window fitted into a reveal has a goodly proportion of its frame covered by the brickwork; generally a margin of

⅞ in. only is exposed round the jambs and the head.

If the brickwork reveals are irregular, it is advisable to face the recesses with mortar or compo, so as to provide a flat surface on which to bed the face of the frame. As described in the fixing of a door frame to an existing opening, a temporary set of linings whose inner edges are straight and true should be fixed over the outside reveals to form a screed. The boards forming the lining should project over the reveal to allow a reasonable thickness of mortar or compo to be plastered over the recesses. The head of the lining should run through the full width of the opening, and be held by the vertical linings, which in turn should be held in position by temporary struts placed across the opening. The screeds may be removed immediately the rendering is complete, or they may be left until the rendering has set.

Plugging Reveals

To give about two or three fixings in the length of the jambs, the inner reveals should be plugged by raking out the mortar joints about every 18 in. apart for a width and depth of about 3 in., and driving properly shaped wedges into the joints. Plugging for the window linings could also be done at the same time. The protruding ends of the plugs should be either cut off to a plumb line so as to leave the net width of the frame between the plugs on each side, or they should be cut flush with the face of the brickwork. In the latter case packing pieces as shown in the diagram must be carefully inserted between the plugs and the frame.

The protruding horns on the sill and head of the frame should then be cut square to leave an equal margin on both sides, so that the frame fits fairly tight between the reveals. Folding wedges should then be inserted over each jamb, as shown, and driven in tight, so that the frame is secured with the sill level and the jambs plumb. The frame should then be securely nailed to the plugs.

Wood Linings

If the window is to be finished with wood linings, the window board should be fitted first. This should be arranged to project over the face of the wall a distance equal to the combined thicknesses of plaster, architrave and nosing, and should be tongued to the sill to cover any possible shrinkage. It should be cut round the opening to allow for the width of the architrave, and the ends of the nosing should be returned in itself, as shown on the left-hand side of the plan in Fig. 19. Fixing is usually done by tosh nailing, that is, by nailing at an angle through the face of the board into the frame, and by nailing into the plugs in the brickwork. Packing pieces should be inserted over each plug to form a solid fixing across the board.

Jamb linings may be merely butted together, or they may be tongued and grooved or housed into the soffit and window board. As they are fitted between the soffit and window board, they should be marked out direct from the grooves in the frame before the horizontal members are fixed in position.

In an old building it is highly probable that the lintel which spans the opening is of wood, in

which case the fixing of the soffit is a simple matter. If the lintel is of concrete, and fixings have not been provided by bedding dovetailed strips of wood in the concrete, holes of $\frac{3}{8}$ in. or $\frac{1}{2}$ in. diameter and about 2 in. deep should be punched into the surface with a star drill, or bored with a modern "morse" drill; then roughly squared plugs should be driven in and sawn off flush with the surface.

When the linings are fitted, packing pieces should be inserted over the plugs, and the faces of the linings tested for squareness by placing a try-square against the frame. At this stage the plastering should be made good, so that the wall surface is flush with the edges of the linings. To cover the joint between the plaster and the wood linings, architraves or cover mouldings are fitted round the opening. These should be kept back about $\frac{1}{8}$ in. from the faces of the linings to mask the joints between the members. In this class of work the architraves are generally nailed to plugs in the walls and also to the edges of the linings.

Fitting the Architrave

The top length of an architrave should be fitted first by cutting one end in a mitre box and shooting the joint with a block plane. It should then be placed in position and the exact length marked directly from the linings. When cut, the top piece should be temporarily nailed in position, so that the lengths of the side pieces can be readily obtained by holding the architrave to the window and marking the height directly from the mitre, as shown in Fig. 19. The mitres are generally secured by inserting nails through the top edge of the top piece and at right-angles to the mitre before the remaining nails are permanently driven in.

When decayed window boards have to be renewed the old board should be removed by first scraping the paint to discover the positions of the fixing nails, then punching the heads through the board, and finally chopping out without any disturbance of the jamb linings.

Routine Repairs

Repairs to cased or boxed frames and double-hung sashes may be considered a routine task for the joiner, because this type of window is invariably found in the older buildings. Thus the joiner should be familiar with the detailed construction and the various parts of the frame, as shown in Fig. 20. The sashes, both of which may be moved vertically in grooves formed in the frame, are suspended by either sash cords or chains which pass over grooved pulleys housed in the members called pulley stiles, against which the sashes slide. They are balanced by cast-iron weights contained within the boxes formed by the frame.

The sill of the frame is solid, but the jambs and head are formed from four boards which in the jamb are known as pulley stile, inner and outer linings, and back lining. The edges of the pulley stiles may be tongued into the linings, or in cheaper frames merely butted, while its face is grooved to receive a parting bead to form a track for the upper sash.

A track for the lower sash is formed by the parting bead and an inner or guard bead, which is detachable. Access to the weights

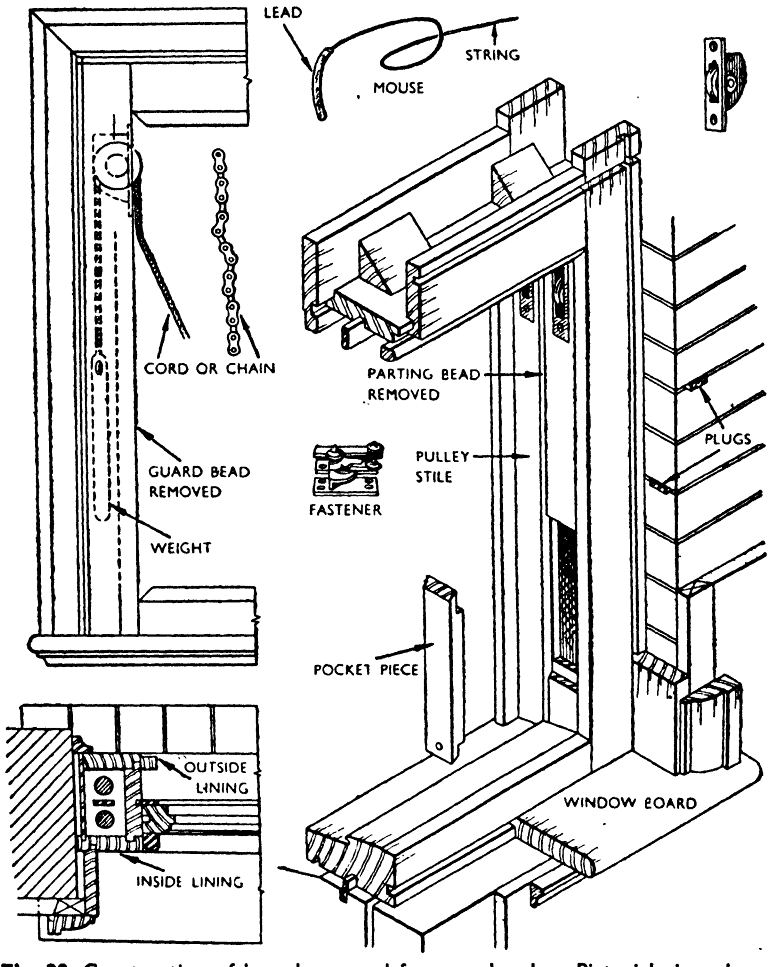


Fig. 20. Construction of boxed or cased frame and sashes. Pictorial view shows the pocket removed to re-cord the sashes. The sashes are balanced with cast-iron weights to enable them to slide easily. Sashes may be hung to cords or chains as shown. The "mouse" is used to thread the cord over the pulleys.

is given by cutting a pocket piece in the pulley stile, and the weights are separated by a suspended parting slip or wagtail in the centre of the casing.

Apart from the individual details of any particular job, the fixing of a cased frame and the method of finishing are similar in every respect to the methods previously described for a casement window.

The most frequent type of repair concerns the replacement of broken sash cords. This is a remunerative item to the builder if the work is tackled in a systematic manner, which should include

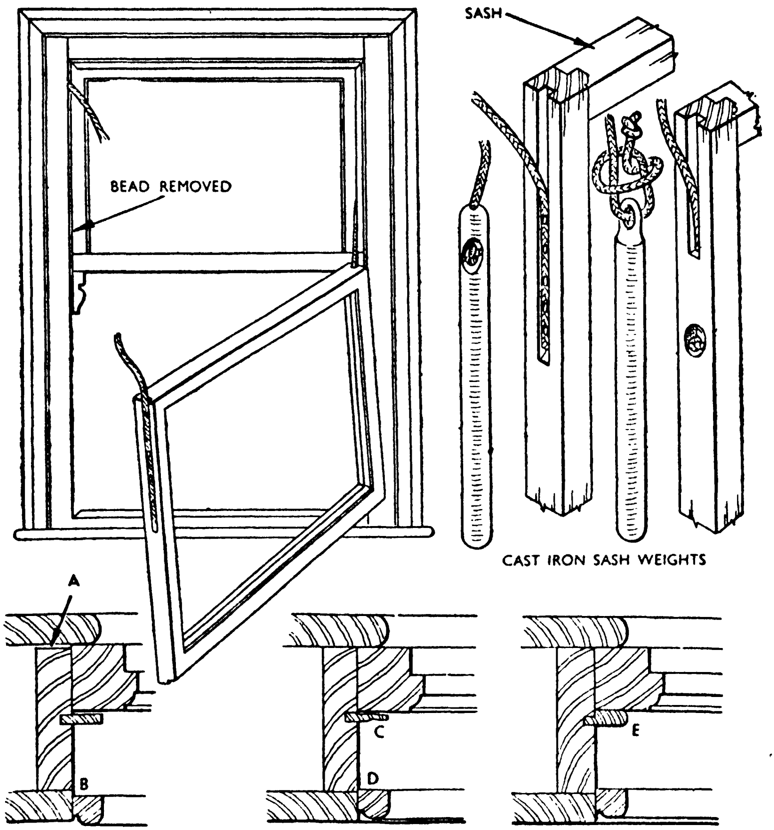


Fig. 21. Repairs to sashes and frames showing methods of attaching cord to weights and sashes. *A.* Rattling sash due to outer lining warping; *B.* due to improperly fixed guard bead; *C.* worn parting bead; *D* and *E.* how to make adjustments.

a complete overhaul of the various members of the frame. Causes of repeated breakages should be carefully examined and rectified. They may be due to worn or ill-fitting pulleys, or to the weights jamming in the casings. Many of the older windows are not constructed with a back lining or parting slip; consequently, a sudden slamming of the sash is likely to foul the weights and to rub and strain the cords.

It is generally more economical to replace sash cords in pairs, or, better still, to replace all four cords at the same time; for if a cord breaks after long use, the others must be well worn, and repeated dismantling of the beads tend to disfigure the paintwork.

Removing Guard Beads

The guard beads on each side are removed by carefully inserting an old chisel in the centre of the length and levering the bead out by pulling the nail heads through the wood. This minimises damage

to the paintwork. The bottom sash is then taken out, as shown in Fig. 21, and the old cord and nails removed from the groove in the sash. The parting bead is then extracted first by tapping lightly with a hammer to break the paint at the joint, then the top sash is removed and its edges cleaned. The top sash should then be held in the frame in its position when fully open, and the lengths of the grooves marked on the frame as a guide to the length of cord required. The positions of the grooves in the bottom sash when closed should also be marked on the frame.

The pocket pieces should then be taken out to give access to the weights. When the old cord has been detached from the weights, the new cord should be threaded over the pulley wheels and drawn through the pocket at the bottom. New cord should always be well stretched before use by tying one end to a securely fixed object and heaving at the other end.

Threading the Cord

Threading the cord is simplified by using a mouse to which the cord is temporarily attached. This consists of a piece of sheet lead about 3 in. long, beaten round the end of a length of string so as to form a flexible weight which will pass over the pulley, as shown in Fig. 20. To avoid re-tying the mouse to the cord for all four pulleys, it should be threaded in the following order: through an inside pulley and out of the pocket; in through the opposite inside pulley and out of the pocket; from there to the outside pulley and out of the pocket to the opposite outside pulley.

The outside weight for the top sash should then be tied on, according to the type of weight as shown in Fig. 21, and then hoisted up to the full height of the pulley. The cord should then be temporarily fixed with a clout nail to the pulley stile and cut to the correct length as indicated by the marks previously made on the frame. The opposite outside weight should then be tied on and the cord temporarily nailed and cut to length; then the inside weights should be dealt with in a similar manner. The pocket piece should then be replaced, and if necessary secured with a larger-size screw.

Attaching the Sash

According to its construction, there are two methods by which the sash may be attached to the cord, as shown in Fig. 21. One is to nail the cord with clout nails in a groove cut into the edge of the stile, while the other is to tie the cord to the sash. In the last-mentioned method the sash has a $\frac{3}{8}$-in. hole bored in the end of the stile and a 1-in. hole bored at right angles to it. The cord is passed through the smaller hole and tied into a knot which fits in the larger hole. In both methods it is important that the top six inches of the cord is left free, so that the sash can be lifted over the pulley to the top.

The beads should then be cleaned and refixed by placing the ends in position, first by bending the bead outwards in the middle of its length. If possible, the nails in the guard bead should be guided into their original holes in the frame, and should not be knocked back through the wood. In good-class work the use of cups and screws instead of nails greatly facilitates and simplifies refixing.

Stiff sashes should be eased by smoothing off the thick accumulations of paint on the arrises with glasspaper, while rattling sashes should be corrected. A loose bottom sash is generally due to the guard beads not being replaced properly, as shown in Fig. 21 B. The remedy for this is to refix the beads more tightly against the sash, as shown at D.

The rattling of a top sash is a different matter. It may be due to the outer lining warping, as shown at A, or the parting bead may be ill-fitting or worn, as shown at C. The adjustment of the sash fastener to pull the meeting-rails closer together may help, but the only satisfactory way of dealing with a loose top sash is to fit thicker parting beads. These may be "backed off" or rebated to fit the existing groove, as shown at E. Wedges to stop the sashes from rattling should only be used as a temporary measure.

Stair Construction

Generally the best constructed item of joinery in a domestic building is the stair. This seldom develops any serious structural defect, repairs being confined to replacing or patching worn members. A stair is composed of a series of steps formed by comparatively thin boards called treads and risers, the ends of which are housed into and securely wedged to inclined boards called strings, as in Fig. 22. Generally one string butts against a wall, while the other, called the outer string, is tenoned and pinned to the newel posts which support the handrail.

The treads and risers should be tongued and grooved together with their edges glued and screwed. Sometimes they are merely butted together, as at A, or in some districts nailed together as at B. The nosing—that is, the rounded projection of the tread over the riser—is generally supported by a scotia moulding housed into the tread or butted against its surface. To give additional rigidity to the steps, all internal angles on the underside of a stair should be fitted with glued angle-blocks as shown in the diagram. In stairs over 3 ft. wide an intermediate support must be inserted in the form of a stout scantling called a carriage, to which are nailed brackets to support the centre of each tread.

Workshop Assembly

A stair is fixed as a complete unit, and as much of the construction as possible should be completed in the workshop; but precautions must be taken to ensure that the stair will pass through the building into its position. In awkward situations the final fixing of the newel posts and handrails should be left until the stair is in its place.

A stair is fixed by notching the top newel post and the top of the wall string over the landing trimmer, so that the boards of the landing form the top tread. The bottom newel post is spiked to the floor, while the wall string is cut to butt against the skirting board. Intermediate fixing is obtained by plugging the wall and nailing the string below the treads to the plugs. Two or three fixings in the length of the stair are usually quite sufficient to prevent deflection.

The actual erection of a stair does not present any unusual difficulties, providing the sizes are correct. It should be hoisted into position and temporarily held from

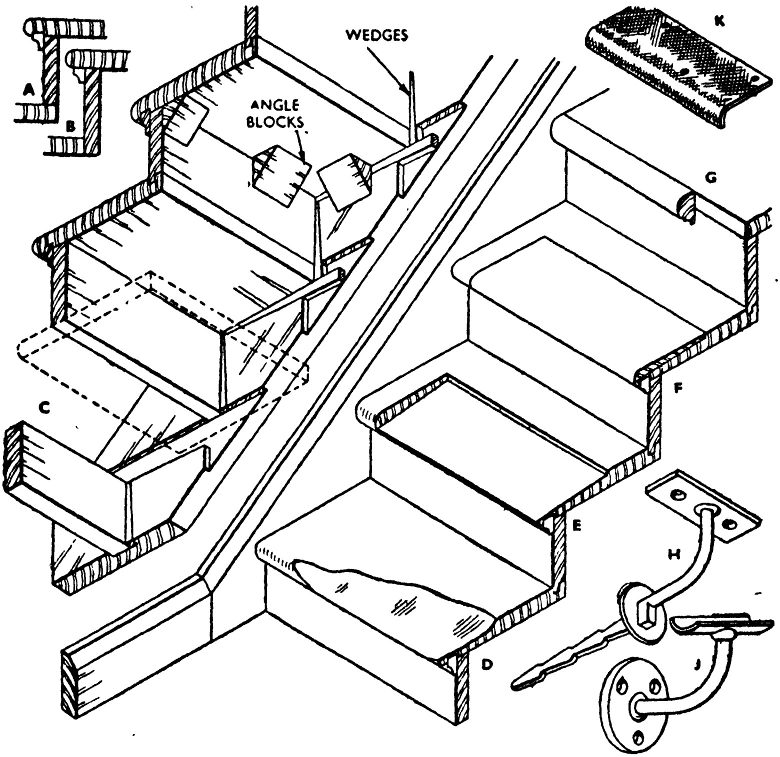


Fig. 22. Stair construction showing how treads and risers are housed and wedged into the strings. *A.* Risers butted between the treads; *B.* cheap construction where riser butts against the tread; *C.* how to slide a new tread into position; *D. E* and *F.* stages in patching a worn tread. *G.* solid member shaped to the profile of the nosing and scotia moulding; *H.* metal bracket driven into wall to support handrail; *J.* metal bracket screwed on wall to support handrail; *K.* non-slip tread cover.

sliding outwards by nailing a block of wood to the floor. The stair should then be fitted, taking care that the steps are level and the newel posts plumb.

Fixing Balusters

Balusters may be fixed before the stair is delivered, or they may be fixed when the stair is in its proper position. In the latter case they must be evenly spaced, parallel with the newel posts and each other. Usually balusters are housed into the underside of the handrail and tenoned into a capping on top of the string. To allow the balusters to slide into position during fixing, and to cover the splayed joints, the handrail is generally grooved on its underside.

Renewal of Worn Treads

Worn treads should be renewed, patched or covered. To replace a damaged tread without disconnecting every member in the stair, the wedges should be cut out, angle blocks chopped off, and the

fixing screws removed. The tread should then be loosened and knocked out. In difficult places and with tenacious treads such as those nailed through the strings, it may be necessary to cut the tread across its face into three parts, so that the nailed ends can be levered out.

Much depends upon the construction of the particular stair. In some stairs the scotia moulding is merely pinned in position and can easily be levered off, while in others the moulding may be so well glued that it must be chopped off with a chisel. Tread housings should be cleaned by chopping out all old glue, the new tread cut to the correct length and the nosing scribed to the string. Tongues may have to be stripped to enable the new tread to slide into its position as in Fig. 22 C.

New wedges should then be inserted to force the tread tight in its position, screws inserted into the strings and risers, and angle-blocks well glued and rubbed into place. If more than one tread is to be replaced, the angle-blocks should be left until all the treads are fixed. Sometimes the plastered soffit of a stair makes the replacement of treads rather involved. In such a case it may be better to patch the worn portions in preference to renewing.

Tread Patching

Patching may be executed as shown in Fig. 22 D to F. As the wear on a tread invariably produces a concavity in the centre of the nosing, as at D, it should be cut out as at E, and new material inserted as at F. This patch should be glued and pinned into position, and the edges smoothed off flush with the face of the tread. Broken nosings should be cut off flush with the face of the riser and replaced by a solid member shaped to the profile of the nosing and scotia moulding as shown at G.

Covering worn treads may consist of cladding the steps with fairly thin wood, covering with sheet cork or rubber, or by fixing special metal treads faced with fabric or other non-slip material, as at K. These are obtainable in standard sizes in multiples of 3 in. from 24 in. to 42 in. in length, and in widths of 2½ in., 4 in., 6 in. and 8 in., including the nosing.

Loose Members

Squeaking or creaking in stairs is due to the rubbing of loose members, and can generally be traced to the movement of the scotia moulding against the face of the riser when weight is suddenly applied on the nosing of the tread. The remedy is to overhaul the steps, gluing loose members and inserting nails or screws where necessary. Loose joints should be well dusted before the glue is applied, and all superfluous glue should be cleaned off the face of the work immediately the nails or screws are inserted.

Broken balusters should be replaced, while turned balusters should be repaired first by gluing the jagged breakage, allowing the glue to set, and then cutting across the joint to insert a hardwood dowel. The cut should be made below some projecting member, so as to be as inconspicuous as possible.

Additional handrails are often required to be fixed to the wall of an existing staircase. These are supported by metal handrail brackets which may be driven into plugs driven into the wall or

screwed to the face of the plugs. Both types of handrail brackets are shown in Fig. 22 H and J. The rail itself should be of a simple section, easy to grip, and should be fixed parallel to the pitch of the stair at a height of 2 ft. 7½ in. measured vertically from the top of the tread immediately over the face of the riser to the top of the rail.

Protective Sheathing

When a valuable building is leased as offices, the builder is sometimes called upon to encase the stair by sheathing the woodwork to protect it from damage. Such a construction consists of treads and risers which rest upon the original members and which are held in place by notched strings fitted over the steps. The balustrade is completely covered with plywood or fibre boards fixed to studs which are wedged between the balusters.

Skirting boards are fixed round the walls of a room or landing to protect the wall surface at a point subject to hard wear, and to conceal the junction between the wall plaster and the floor covering. They should be of the same material as the floor covering; thus for a wooden floor the skirting may consist of a plain, flat board or of several members decorated with mouldings.

The present trend in design is towards simple shapes which can be easily cleaned, but the joiner may be called upon to reproduce or repair the larger and more ornate types of skirting. Hence a brief description of the various methods employed in fixing is desirable.

In ordinary domestic work the skirting board is secured to the wall by nailing directly either into plugs driven into the vertical joints of the brickwork, as in Fig. 23 A, or into breeze fixing blocks built into the wall. Plugs should be spaced not more than two or three bricks apart, and, where the depth of the board allows, they should be staggered to provide a fixing at both the top and bottom edges. To afford a guide for the plasterer and to maintain a straight surface, plugs should be marked and cut to a chalk line stretched parallel to the wall at a distance equal to the thickness of the plaster.

A better fixing for skirting boards, especially for deeper boards, is to erect vertical fillets, called soldiers, at intervals along the wall. This provides a flat surface for fixing, as is shown at Fig. 23 B.

Rough Grounds

In good-class work, rough grounds should be used, as shown at C. These are battens 2 to 3 in. wide, and of the same thickness as the finished plasterwork. All grounds should be machine planed on all faces, and should be treated with some water-soluble preservative before they are fixed to the wall. Rough grounds not only afford a guide for the plasterer and enable the skirting to be fixed when the plasterwork is dry, but they provide a true flat fixing surface which will hold the boards true.

The space formed by the grounds or plugs behind the skirting should be filled with plaster in order to avoid a possible harbourage for vermin and to prevent the accumulation of dirt.

A wide skirting board is liable to shrink and expose an open

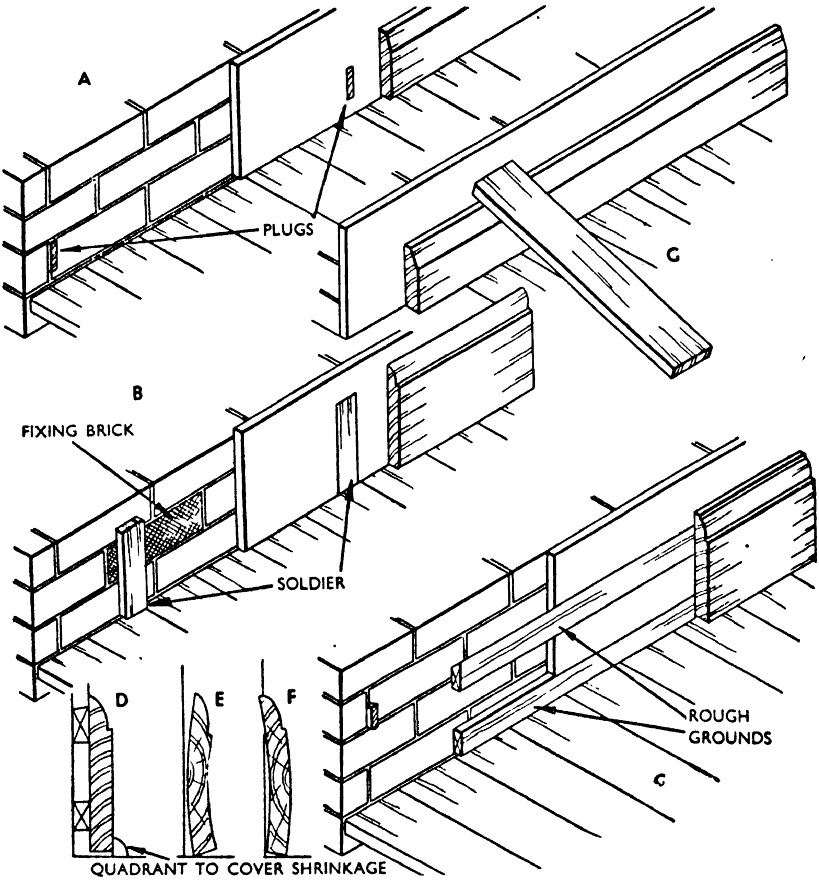


Fig. 23. A. Plugs driven into brickwork joints; *B.* vertical soldiers fixed to breeze bricks to provide a flat surface for fixing; *C* and *D.* rough grounds plugged to wall; *E* and *F.* effects of shrinkage; *G.* cramping skirting.

joint between the bottom edge and the floor covering, as shown at Fig. 23 D. In new buildings this gap is likely to be aggravated by the shrinkage of the floor joists and settlement at the wall bearing. Because of this, skirtings should be made from dry, well-seasoned material, fixed when the building has dried out, and they should be scribed to the floor. Skirtings should not be nailed to the floor, as this would augment the defects by causing splits along the lower edge.

Wherever possible, skirtings should be selected from rift sawn material (Fig. 23 C) to prevent the boards bowing, as at E. Alternatively, the heart side should be on the outside of the board, to counteract the warping. A skirting cut as shown at F tends to tighten against the wall surface instead of curling away to leave an extremely unsightly gap at the top edge.

To scribe a skirting to fit any unevenness in a floor, the board should be levelled by packing one end; then the lower edge should be marked with the dividers set to the greatest distance between the skirting and the floor. Waste should be removed with a sharp axe, slightly undercutting the edge to ensure a reasonable fit to the floor. During fixing operations, the joiner should hold the skirting firm against the floor by kneeling on a length of floor boarding placed on the top edge of the skirting, as at Fig. 23 G.

External angles should be mitred together and fixed by inserting nails through both faces into the mitre, while internal angles

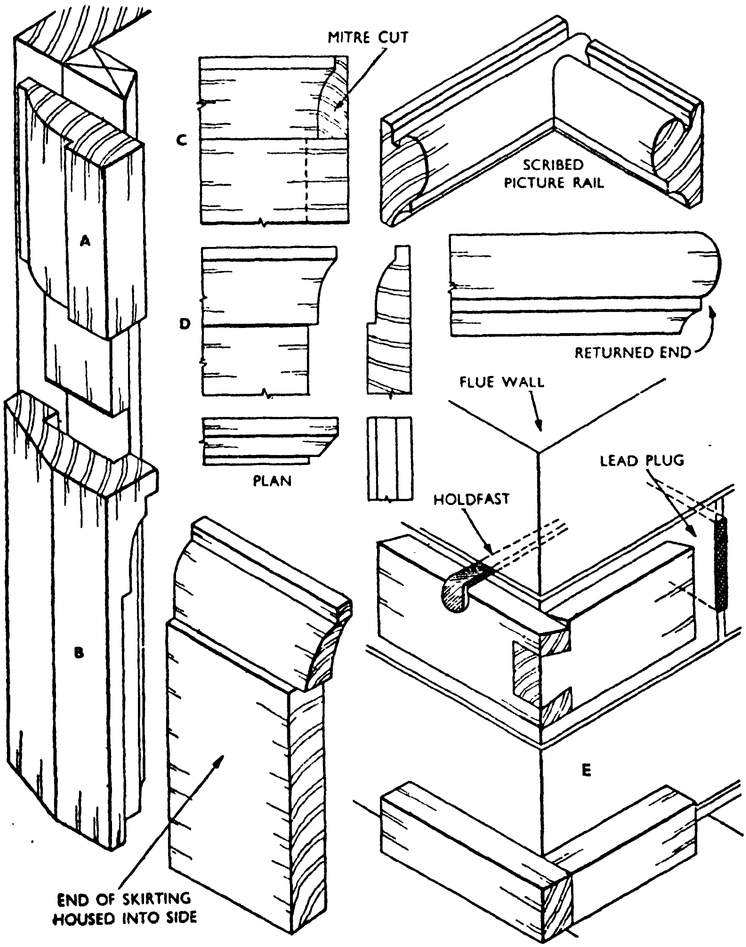


Fig. 24. Finishes to skirting boards and picture rails. A. Finish at foot of doorway showing architrave tenoned to plinth block *B*; *C* and *D*. methods of scribing skirting; E. skirting round fireplace opening; a scribed picture rail is also shown.

should be scribed together, as shown in Fig. 24 D. The longest length of skirting is generally fixed first, with its ends butted against the return walls. Adjacent skirtings are then marked for scribing by cutting the ends in a mitre block to give the profile of the moulded portion, shown at C. It is only necessary to cut a mitre on the shaped part, as the flat portion should be cut square to butt against the face of the fixed skirting.

The actual scribing of the moulded portion should be made with suitably shaped scribing gouges or cut with a fine coping saw. In better-class work the flat portions of the skirting should be tongued and grooved together, in order to preserve a true angle at the joint.

Fig. 24 also shows the finish at the foot of a doorway in good work. The architrave A is tenoned into the back of the plinth block B, while the end of the skirting is housed into the side. This arrangement holds the members together and avoids the unsightly warping which causes the architrave and skirting to stand at various projections from the face of the plaster.

The fixing of skirting around fireplace openings calls for special consideration. Wooden plugs are prohibited by the by-laws as likely to cause fires, hence where grounds are required to be fixed to a flue wall they should be held either by metal holdfasts or lead plugs, as in Fig. 24.

Loose skirtings are generally due to faulty fixing methods. In old work, wood fixing bricks were often used to provide a fixing for the joinery. These invariably become loose, and are prone to decay, with the resultant loosening of the skirting. In such cases it is advisable to remove the loose board and to discard the wood bricks, then insert breeze fixing bricks or plug the wall for wooden plugs.

On damp walls the skirting is probably partly decayed, and the treatment must be drastic, as previously described. Gaps between the bottom of the skirting and the floor should be concealed with a small quadrant fillet nailed to the floor, as in Fig. 23.

Picture Rails

Picture rails as shown in Fig. 24, are generally fixed at the same height as the architrave on the door head to form a frieze. The rails are nailed either to narrow plugs or to fixing bricks built into the wall. To ensure that the rail is level and straight, the ends should first be fixed to marks measured from the floor or ceiling, then the length should be sighted and straightened. Alternatively, a chalk line should be stretched across the wall to provide a guide.

To fix a picture rail to a plastered wall, or to fix a loose or sagging rail, circular plugs, as described in Chapter 5, should be inserted through the plaster into the brickwork.

In repair work it is often necessary to replace a moulded member to match the existing joinery. To obtain a true replica of the moulding, the outline should be obtained by cutting a section of about 1 in. long from the damaged member, or by preparing a templet of plywood, sheet zinc or cardboard cut to the profile of the moulding as shown in Fig. 25 A or B. This templet, together with a list giving the number of feet run in minimum lengths, should be sent to the workshop for the material to

be prepared in advance on the spindle moulder.

Sometimes it is more expedient to "stick" the moulding by hand methods. For this method the sequence of operations is important. Straight-grained material should be selected, free from defects, and with the grain arranged to run in the direction of the planing. This should be planed to the correct size, and the profile of the moulding marked on both ends, or a pair of templets pinned to the ends, as at Fig. 25 C. Grooves should then be cut either on a circular saw or with a plough plane, as shown at D. Their positions must coincide with the flats or fillets on the moulding so as to form a guide for shaping.

The surplus material should then be chopped out with a chisel and levelled with a rebate plane to

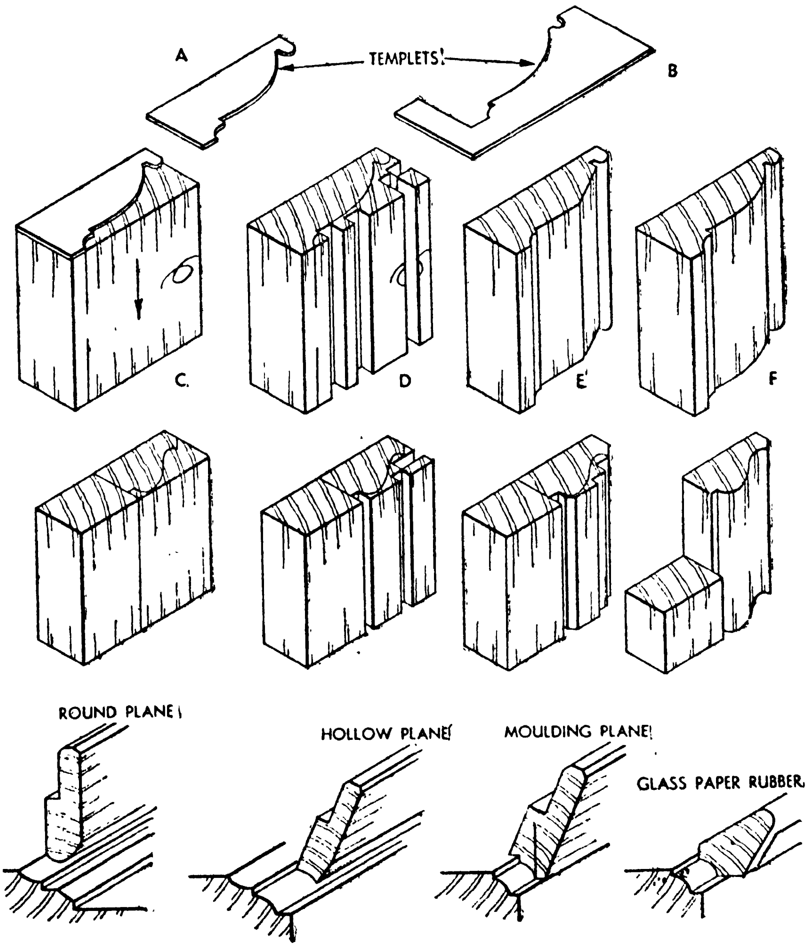


Fig. 25. Detailed procedure in preparing moulding by hand methods; C to F show the various stages. Small mouldings should be stuck on the edge of a wide board.

give the shape shown at Fig. 25 E. Waste should be further reduced by a series of chamfers, and then the material shaped with hollow and round planes.

The members should then be worked to the final shape with glasspaper, starting with a coarse grade and finishing with a fine paper. Glasspaper should be used with specially shaped rubbers of cork or pine, as shown in Fig. 25. Sharp arrises and flat surfaces should be maintained throughout. As a precaution against rubbing undesirable facets on the moulding, the flats on the rubber should extend beyond the arrises, as shown. Small mouldings should be worked on the edge of a wide board to give rigidity during shaping operations, and should be cut off when the moulding is complete.

Installation of Fitments

The installation of joinery fitments provides an extensive part of the work of the small builder. The joinery has to be made for a specific purpose to fit a particular position, and includes storage

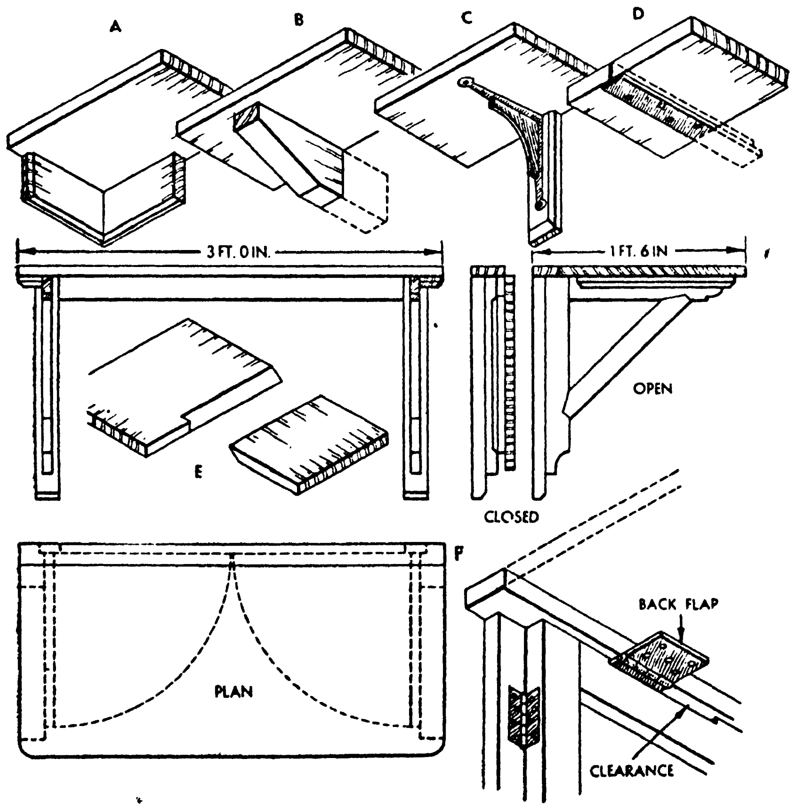


Fig. 26. Fixing open shelves. *A.* Cleats plugged to wall; *B.* 3 × 2 in. nog built-in; *C.* metal bracket screwed to cleat; *D.* T-iron built into wall; *E.* junction of shelves; *F.* folding table fixed to wall. Detail shows parts hinged together.

cupboards of all kinds, toilet cabinets, shelves for food, dry goods, books and china, kitchen equipment and fitted furniture.

Unless the fitments are easily accessible, their practical value is negligible; for example, many well-spaced narrow kitchen shelves are better than a few wide shelves. A 9-in. width will accommodate two rows of jars, and if spaced 16 in. apart will allow ease of handling and accessibility.

Supports for Shelves

Open shelves may be supported by cleats nailed to plugs in the wall, as shown in Fig. 26 A, or their ends may be fitted into chases cut into the brickwork. Intermediate support may be in the form of tapered nogs, as at B, which are fitted and wedged into the wall; or by plugging a vertical cleat to the wall and supporting the shelf by metal brackets, as at C. A less cumbersome method is to insert small tee-irons into the wall, as at D, in which the shelves are cut to fit against the web of the iron and secured by screws through the flange.

When a shelf is fixed to fit at right-angles to another in a corner, the joint between them should consist of a splayed housing (Fig. 26 E).

Fig. 26 also shows the details of a small folding table suitable for a kitchen. The top is supported by two folding brackets, which are hinged to a frame plugged to the wall. The top is also hinged to fold over the brackets when closed. The top of the wall frame must be securely fastened, as this portion is subject to the greatest stress.

Fig. 27 shows the constructional details of a joiner-made cupboard with drawers. The front is made of 2 to 3 in. × 1¼ in. softwood, framed together with the drawer rail and division placed edgewise. The carcase top should be buttoned to the bearer rails to allow the material to shrink and swell without causing unsightly defects.

Drawer runners should be fixed flush with the top of the drawer rail, and dust boards inserted to protect the contents of the cupboard below. When the carcase is complete, the drawer fronts should be fitted to the frame before they are jointed to the sides. They may be flush with the frame or rebated to lap over the face. Drawers are dovetailed together, as shown in the diagrams, or in cheap work merely tongued and grooved together. The back should be made narrower than the sides, to allow for the fixing of the bottom and to avoid fouling the carcase when sliding.

The detail at Fig. 27 A shows a section through the side of a drawer and its relation to the opening in the carcase. The kicker is to prevent the drawer dropping or kicking when open to its full extent, while the guide, which is glued and pinned to the runner, is to enable the drawer to slide smoothly without jamming.

At B the hardwood strip serves as a runner as well as a guide, and is a sound method for kitchen drawers, as there is less likelihood of the drawer sticking due to the wood swelling. This detail also shows the bottom fixed with a drawer slip glued and pinned in position.

Maintenance work invariably includes the easing of jammed drawers. Before any material is planed off the sides of the drawer, the guides should be inspected, as a jammed drawer is generally

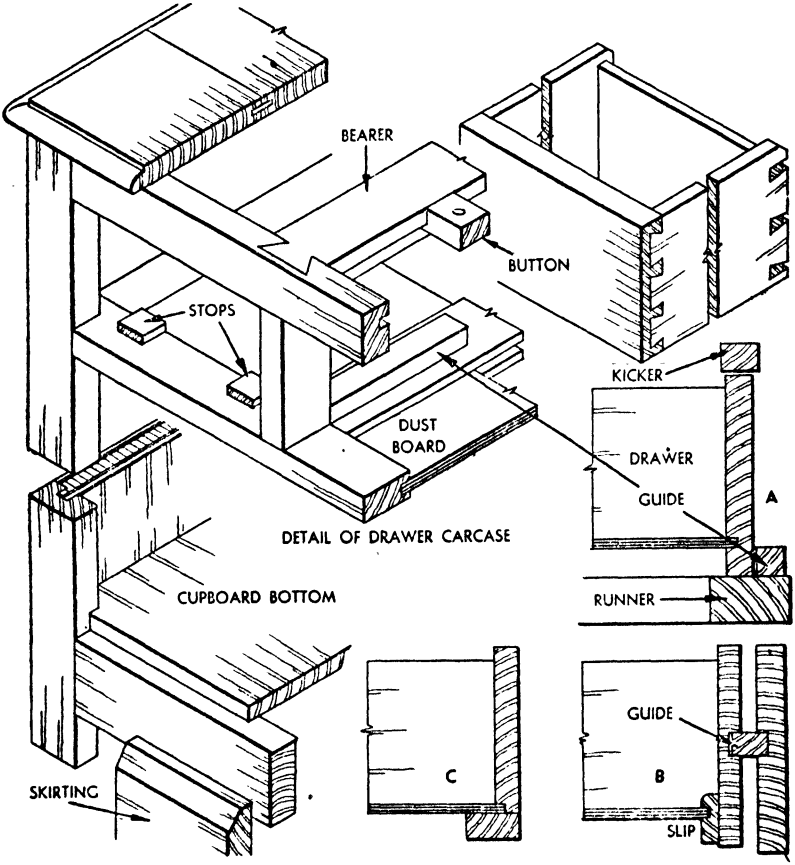


Fig. 27. Built-in drawer carcase and cupboard. *A.* Section through drawer side to show runner and guide. The kicker prevents the drawer dropping when open to full extent; *B.* drawer suspended by centre runner; *C.* repairs to worn drawer.

due to a slackness, which allows it to become wedged instead of sliding smoothly. The detail at C shows how to repair a worn drawer by the addition of a runner attached to the bottom of the drawer side.

Table tops and shelves for the kitchen should be made of European whitewood, because of its clean appearance and lack of smell. When the cost will allow, sycamore, birch or other clean-looking, close-grained hardwood should be used.

The main constructional material for interior fittings is plywood. This term covers the many forms of boards built-up with veneers—that is, with thin sheets of uniform thickness produced by slicing or sawing logs or by rotary cutting.

Multi-ply boards, as shown at Fig. 28 A, are made up of an odd number of veneers cemented to-

gether, and arranged so that the grain of one veneer is at right-angles to the grain of the adjacent veneer. These boards are obtainable in 4-ft. and 5-ft. widths, up to 10 ft. long and from $\frac{1}{8}$ to $1\frac{1}{4}$ in. thick with three to nine plies.

In laminboards (Fig. 28 B) the core is of composite vertical formation instead of horizontal sheets of veneer. This vertical core consists of veneers not exceeding 7 mm. in thickness cemented to each other and laid at right-angles to the grain of the facing veneers. They are usually obtainable in varying sizes up to 7 ft. wide, and 15 ft. long, and from $\frac{3}{8}$ to 2 in. thick.

In blockboards (Fig. 28 C) the core consists of strips not exceeding 1 in. wide, while in battenboards the core is of strips up to 3 in. wide; sizes are as laminboards. Plyboards may be obtained with a metal facing fixed to one or both faces, and with various insulating material incorporated in the core, such as asbestos, lead or bakelite. Improved wood is a further development of plywood in which the veneers are impregnated with synthetic resin and subjected to a very great pressure, to give a hard and dense material which is immune from warping.

Plywood has many definite

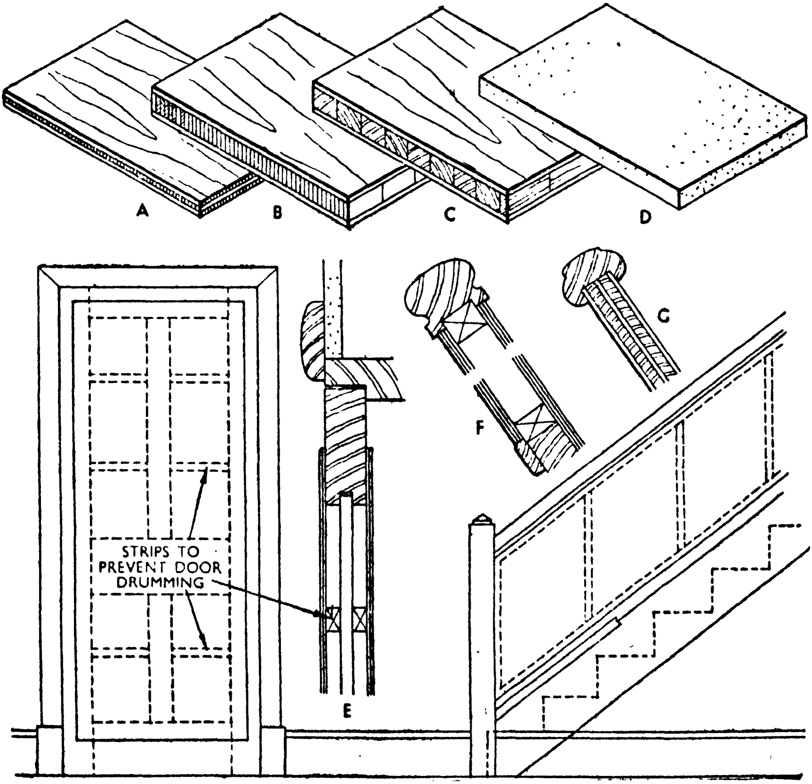


Fig. 28. Various uses to which plywood may be put in modernising domestic woodwork (*E, F, G*). *A.* Plywood; *B.* laminboard; *C.* blockboard; *D.* fibre board.

advantages over ordinary wood, and is specially adaptable for repair or alteration work. It will not split along the grain or swell and shrink across the grain, and is obtainable in wide boards, which allow of great width to be formed without joints.

Modernising Woodwork

Fig. 28 illustrates the use of three-ply to modernise domestic woodwork. In the example of a door a thin plywood sheet is cut to leave a margin, as shown at E. This avoids altering the casing to allow for the extra thickness, and does not require a lipping on the edge of the door, as would be necessary if the ply were to cover the entire face. The sheet is merely glued and pinned at its edges to the face, with additional strips inserted over the panels to prevent the door drumming.

The second example shows a solid filling to the balustrade of a stair. The existing balusters can be utilised to provide the blocking for the plywood (Fig. 28 F), or a single sheet of stout core plywood or laminboard could be inserted as shown at G. Joints between the sheets should be concealed with cover strips or emphasised by a chamfer to give the appearance of a vee joint.

Fitments are erected in the building without being an integral part of the structure. Their purpose is to take the place of loose furniture, and thus increase the efficiency of the building by saving housework, increasing floor space and enabling the rooms to be better planned. They may consist of specially constructed arrangements made to fit the room, or of prefabricated units which are fitted together in the building.

Fig. 29 shows a typical specially made kitchen fitment with a serving hatch leading to the dining-room, and with storage cupboards and drawers made to suit the requirements of the householder. In work of this kind surfaces should be as plain as possible, easy to keep clean and capable of repeated washing down without serious detriment to the finish. On this account the joinery should be of softwood treated with a hard glossy paint or enamel in preference to a polished hardwood. Mouldings liable to collect dust and retain moisture should be avoided.

Laminated boards considerably simplify construction. $\frac{3}{4}$-in. or 1-in. blockboard, with edgings to hide the end grain, is used throughout. With the exception of the drawer carcase, all the members are connected together with housed or rebated joints secured with nails and glue or screws.

The sliding doors to the storage cupboard A are of plate glass, so that the contents are visible; they slide along a metal strip as shown, or between hardwood fillets pinned to the shelf. Double doors are used for the hatch, to reduce the penetration of sound and smell between the kitchen and the dining-room. Flush surface folding doors to the dining-room are veneered to match the dining-room woodwork, and the door surround is fixed directly to the wall, as shown at B. The inner door is also made from blockboard, and is made to slide horizontally, to avoid sweeping objects off the service table.

Table surfaces should be covered with some non-scratch material such as bakelite or metal-faced ply, and fixed in position by screws through the carcase rail

(Fig. 29 c). Plinths should be recessed, to allow ample toe room when working at the table.

Fitments should extend to the ceiling, and where the top portion is not required as a cupboard it should be filled-in, to avoid becoming a dust trap.

A most important point in fixing any joinery work is to take particular care that all horizontal members are level and all vertical members plumb and out of winding. The appearance of good joinery is frequently ruined through carelessness in this respect. Good fitting is very necessary to good construction.

Although interior decoration in the form of wall panelling and built-in furniture is generally done by a specialist firm, the builder is sometimes called upon to deal with work of this type. Wall panelling may be of the traditional construction, with grooved framing and solid panels. As a general rule the rails should extend across the framing to the end stiles, and should have intermediate muntins stub-tenoned between them.

With laminboards large panels are possible, and there is an increasing tendency to rebate the frame and to fix the panels by fillets instead of grooves, in order to allow for bolder mouldings.

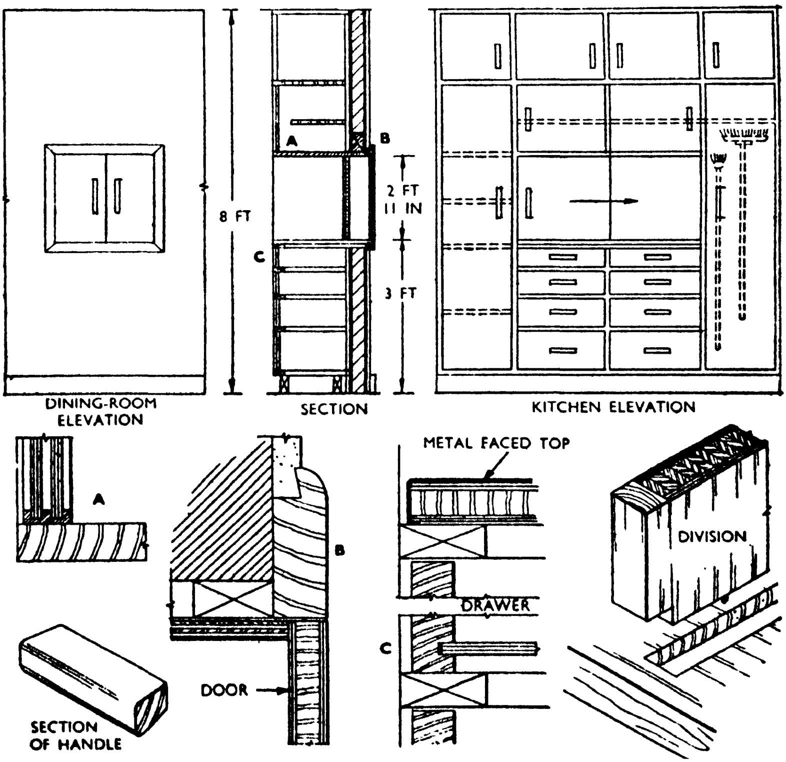


Fig. 29. Typical kitchen fitment with serving hatch leading to dining room.

CHAPTER 5

FASTENINGS

COMMON FASTENINGS. CLASSIFICATION OF NAILS. METHODS OF NAILING. FIXING SCREWS. SECRET SCREWING. PLUGGING MATERIALS. EXTERNAL FASTENINGS. BOLTS. SECURING HEAVY WORK. TYPES OF RAWLBOLTS. TEMPORARY FIXING. JOINING REPAIRS. OTHER FASTENINGS. JOINTING SHEET METAL. ADHESIVES. TREATMENT OF GLUE. SYNTHETIC RESINS.

As repair work consists of replacing damaged portions of the fittings and the fabric of a building it is essential to maintain rigidity throughout the structure, and to ensure as complete a cohesion as is possible between the old material and the new. For the satisfactory execution of building repairs, then, a wide knowledge of the commoner types of fastenings is essential. In this respect, two simple things are of paramount importance. The one is to select the right type of fastening for the particular purpose, and the other is to use it in a proper manner.

Repair work is quite frequently spoiled by indifferent fixing. Nails, screws, bolts, wedges, glues, cements and other fastenings, if improperly or carelessly used, make all the difference between a secure and a precarious fixing, which means, between a good and a bad repair.

Types of Nails

Nails are the cheapest and most convenient form of fastening, and although they are made in a large variety of types for many different purposes, the manner of their insertion and the way in which they hold are common to all types. A nail holds by the pressure of the surrounding material into which it is driven. As shown in Fig. 1 A, when a nail is driven into a piece of wood it severs the fibres, and is held in position by the pressure of the fractured fibres against the surface of the nail.

Distortion of Fibres

Where the material is unequal to the stress set up by the localised distortion of the fibres surrounding the nail, the wood splits. To reduce splitting to a minimum, as thin a nail as can be driven should be used; or, better still, pilot holes should be drilled for the nail to reduce the strain on the fibres. This applies especially to the use of large-size nails inserted in thin boards and at the ends of boards.

Excessive stress may also be caused by the difference of the elasticity of the fibres in different woods. If a nail is driven into a dense piece of wood, it produces a much greater splitting force than when the same nail is driven into a light piece of wood; but the dense wood offers more resistance to splitting than the light wood. These two forces tend to balance each other, but the denser wood is generally harder and less pliable; hence, all hardwoods, and softwoods such as British Columbian pine and pitch pine, should also

have pilot holes drilled for the nails.

As a general rule, the softer and more pliable the material, the smaller the pilot hole; conversely, the harder the material, the larger the hole, both in depth and diameter.

The holding power of a nail varies according to its length, diameter, and the nature of the material into which it is driven; while the longer a nail is, the greater must be its diameter, so that it will drive and not bend easily under the blow of the hammer. A useful rule is to take the length of a nail as two-and-a-half times the thickness of the board to be fixed. For example, a $2\frac{1}{2}$-in. nail is required to fix boarding 1 in. thick, while a $1\frac{1}{4}$-in. nail is quite sufficient for boarding $\frac{1}{2}$ in. thick.

Another most common type of fastening, the wood screw, cuts a spiral track in the fibres of the wood to correspond to its own thread, as shown in Fig. 1 B. This provides greater tenacity, as, in addition to the pressure of the fibres, there is the resistance of the wood against the screw thread.

When a screw is to be inserted to hold two pieces of wood together, the top piece should be drilled to a size slightly larger than the diameter of the shank of the screw, to avoid impeding the screw from drawing itself into the wood. If the shank of the screw has sufficient clearance, there is less tendency for the thread to tear the fibres, as the whole length of the thread can be firmly embedded in the wood before the

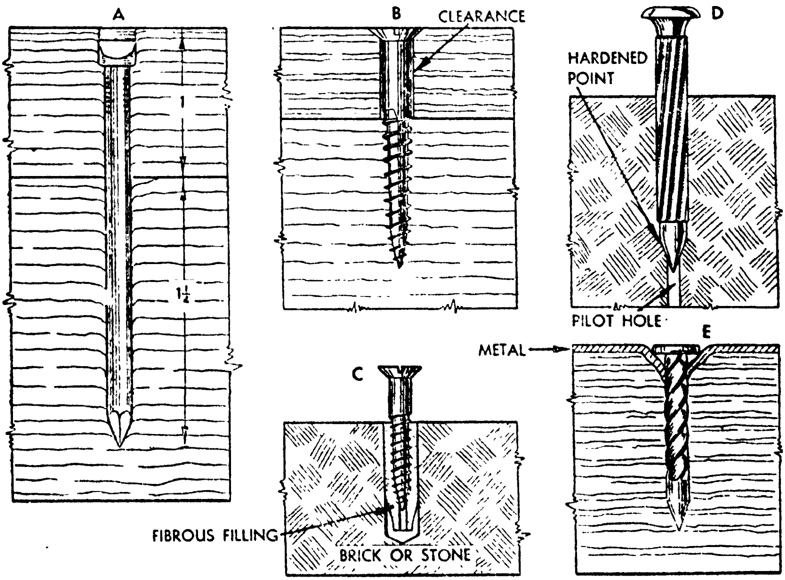


Fig. 1. How fastenings hold by friction. *A.* Nail pierces and compresses fibres of wood; *B.* screw cuts its own thread in wood substance; *C.* hole drilled in stone or brick and filled with fibrous substance to enable nail or screw to hold; *D.* nail with hardened point for driving in soft stone or brick. The edges formed on the shank grip the material; *E.* metal covering held with large headed screw nail.

head of the screw takes the strain of the top board.

To nail or screw a hard material to wood does not present much difficulty. Generally, holes can be drilled through the facing material for large-headed nails or screws. When the conditions are reversed, and wood has to be fixed to a harder material, such as a stone, brick or concrete wall, or a mortar joint, the process becomes more involved. But although the material is less extensible, the same fundamental principles of holding still apply.

One method is to insert pockets of more elastic material to hold the fastenings. Holes or chases may be punched into the wall, and then filled, or plugged, with a fibrous material, such as wood, lead or hemp, into which the fastenings can be driven to obtain a secure hold, as shown in Fig. 1 C. Or special blocks, which are resilient enough to afford a firm grip on the fastening, may be built into the structure itself.

Another way is to use a harder-pointed nail, as shown in Fig. 1 D. This may be driven directly into the softer kinds of wall, as the point drills the material as it is tapped in, and the body is held by the arrises of its fluted surface bearing on the sides of the hole thus formed. For harder material, a pilot hole should first be drilled so that the nail does not rupture the face of the wall—that is, does not exceed the elastic limit of the material.

A screw nail has holding properties similar to that of a screw. One illustration of its value is given in Fig. 1 E, where a sheet of metal is fixed to wood. The vibration set up during nailing would tend to loosen ordinary nails, but the greater holding power of the screw nail obviates the danger of any slackening when hammering adjacent nails.

Classification of Nails

Apart from their size and shape, the main types of nails may be conveniently classified according to the method of their manufacture, as well as by their uses. For example, cut nails are stamped or cut from sheet iron, while wire nails are formed from coils of wire.

Cut nails are obtainable in many forms, of which those shown in Fig. 2 are the main types in common use. Clasp nail, floor brad and rose-headed nail are rectangular in section and are slightly tapered in their length.

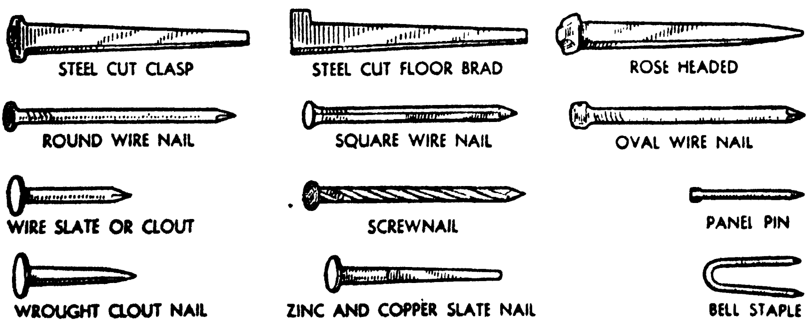


Fig. 2. Main types of wire and cut nails which are in common use.

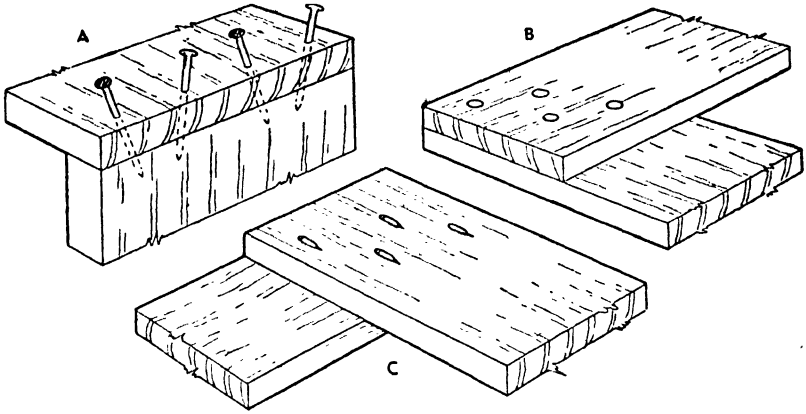


Fig. 3. Use of nails in wood. *A.* Method of "dovetailing" nails in end grain to increase holding power; *B.* nails staggered; *C.* nails clenched in direction of grain.

Their holding power in wood is excellent, and they may be readily riveted or clenched; but they are unpleasant to handle, and they have a tendency to bend and split the wood and leave unsightly holes on the surface of the work.

Wire Nails

A cut nail is generally flat pointed, and the corners of its sides cut the fibres of the wood on being driven, while a bright wire nail, being thinner and smoother, spreads the fibres of the wood. Bright wire nails are now more generally used, as they are much cheaper and are easier to insert, besides giving a neater finish to the work. The cording marks or indentations on the neck of a wire nail are made by the grip of the machine in the formation of the head, and while this irregularity may assist in enabling the nail to grip the wood, it is not intended for that purpose.

The earlier forms of wire nails were often referred to as french nails, but fortunately this confusing term is now becoming obsolete.

The main types of wire nails are shown in Fig. 2. The round wire nail has a round head roughened or serrated to prevent the hammer slipping when nailing. This nail is used for general carpentry and for work in which there can be no objection to the large head showing on the surface.

The square wire nail is designed to cut the fibres more than the round wire nail, and thus increase the holding power in end grain. The oval wire nail is most suitable for joinery work, because the small head can be punched below the surface to conceal the nail. Moreover, its elliptical shape reduces the tendency of the nail to split the wood. Nails oval or rectangular in section should always be inserted with their greater width parallel to the grain, and so minimise excessive strain on the fibres of the wood.

To increase the surface-holding power on thin coverings such as felt and fibre boards, and to prevent the covering being pulled over the nail, extra large-headed nails, as the clout nail, are used.

The screw nail has a series of spiral grooves along its surface, and is designed to give greater holding power and ease of insertion. Because of its screwing action when being driven into the wood, this type of nail is less liable to split the wood. A driving screw is of similar construction, with the exception that a slot is cut in the head to enable the screw to be withdrawn.

Panel pins, sprigs, needle points and lost head nails are thin nails from ⅜ to 2 in. in length. By virtue of their fine gauge, they can be inserted into the thinnest of wood without danger of splitting.

Iron nails will rust if not protected from dampness; hence, for exposed positions, nails should be made of brass or an alloy such as the zinc and copper slate nails. Iron fastenings should not be in direct contact with damp oak, because, owing to chemical action between these materials, the fastenings decompose and stain the substance of the wood.

Nails over 3 in. in length are often referred to as *spikes*.

The semi-circular headed wire staple is used for holding netting, wire and metal to walls, and is obtainable in many sizes.

The holding power of nails is considerably increased if they are inserted at an angle to one another, so that an effect of dovetailing is obtained, as shown in Fig. 3 A. This manner of nailing is especially applicable to nailing in end grain, because of the smaller holding power afforded by the fibres in the direction of their length.

Wherever possible, nails should be staggered, as shown in Fig. 3 B, so as to avoid being in the same line of grain, as this may cause a split and considerably weaken the connection. This particularly applies when effecting repairs to old woodwork, which is often brittle,

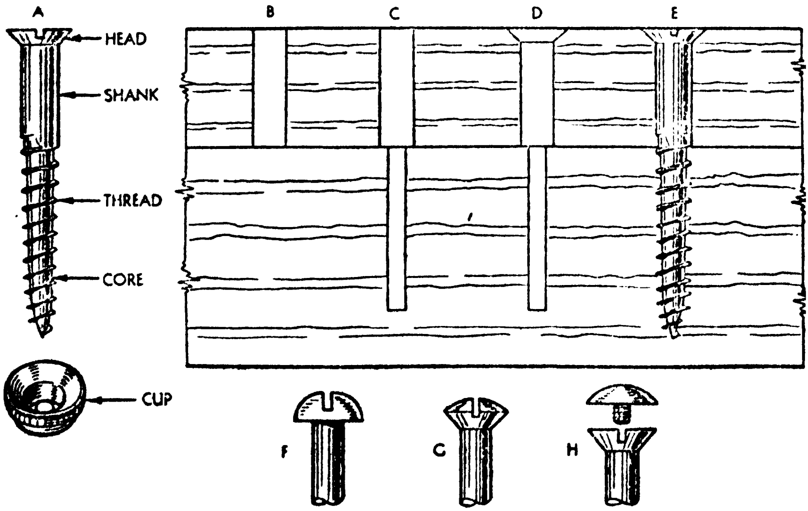


Fig. 4. Wood screws. *A.* Flat-headed screw; *B.* hole bored for screw shank; *C.* hole bored for screw core, in hardwood and for long screws; *D.* countersunk for head; *E.* screw inserted; *F.* round-headed screw; *G.* raised head; *H.* countersunk screw with screw cap. These screws are obtainable in various metals and sizes.

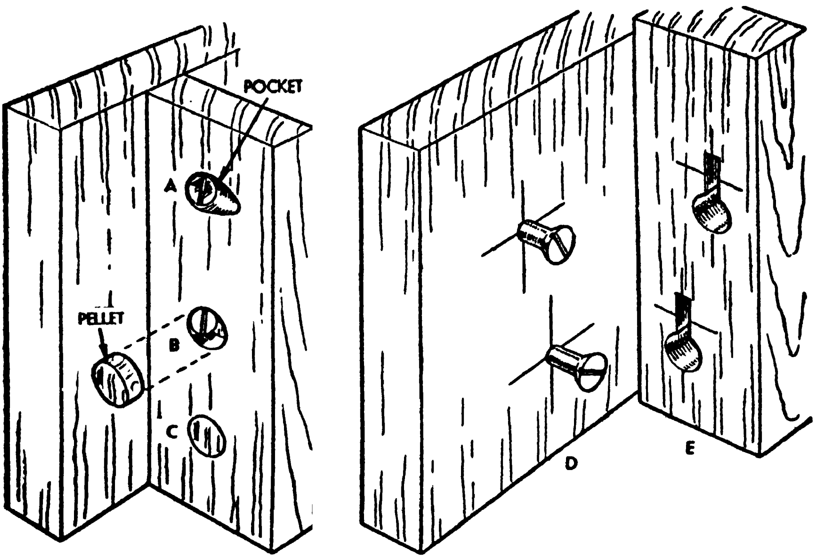


Fig. 5. Methods of screwing. *A.* Pocket screwing; *B.* hole drilled to take head of screw; *C.* hole plugged with circular pellet; *D* and *E.* secret or slot screwing.

and thus susceptible to splitting. Fig. 3 also illustrates how a wrought-iron nail may be riveted or clenched for work subject to shock or continuous vibration. Notice how all the points of the nails are turned over in the direction of the grain, so that they can be hammered flush with the surface, by indenting the fibres of the wood.

Gimlet pointed wood screws, as shown in Fig. 4, are extensively used for fastening pieces of wood together and for fittings to wood. Screws give greater security than nails, as, by their own action, they draw tightly together the parts being screwed and hold them firmly in position. Also they can be inserted without vibration, and can easily be withdrawn and replaced in their original position. They are of reduced value in end grain, as the edges of the thread sever the wood across the fibres.

Screws are obtainable in many sizes, from ¼ to 6 in. in length and from 0000 to 50 in gauge, the gauge being the size of the diameter of the screw shank. With regard to the gauge size, it should be noted that the smaller the number the thinner the screw; conversely, the larger the number the thicker the screw. This is in direct contrast with the wire nail gauge, in which the smaller the number the greater the diameter of the nail.

To avoid unnecessary outlay in repair work, it is wise to stock screws in even numbers between 6's and 14's, in lengths from 1 to 2 in. Correct sized screws for special fittings and odd pairs of hinges can be obtained as occasion demands.

Screws are also obtainable in various metals, such as iron, brass, copper and gunmetal, while the heads may be japanned, galvanised or plated to match the fittings.

Types generally concern the shape of the head, as flat head, roundhead, raised head or with a cap of a finer finish, which can be fitted over the screw head to hide the slot. The flat-headed or countersunk screw is used for most purposes, and should be inserted so that the flat head is flush with the surface being screwed. Where countersunk screws have to be continually removed, brass or metal sockets or cups should be used to prevent a jagged edge wearing round the screw hole. With roundheaded screws, washers should be used for this purpose.

The holding action of a screw depends on the spiral cutting thread and the head. As the screw is turned, the thread bites into the wood and the head draws the members together. To enable the screw thread to function properly, holes should be bored in the wood as shown in Fig. 4 B to suit the shank of the screw; C is to take the core of the screw; and D the head of the screw. Unless these holes are provided, the holding power of the screw is reduced, while with brass screws or in hardwoods, the head is liable to break off or the slot to be damaged.

To facilitate insertion, to prevent rusting and to allow the screw to be removed easily, the points of screws should be tipped with some lubricant before driving.

In fixing woodwork, screws should be inserted in such a position that their heads are hidden from sight by mouldings, otherwise they should be sunk below the surface of the wood and the heads covered with pellets. Some-

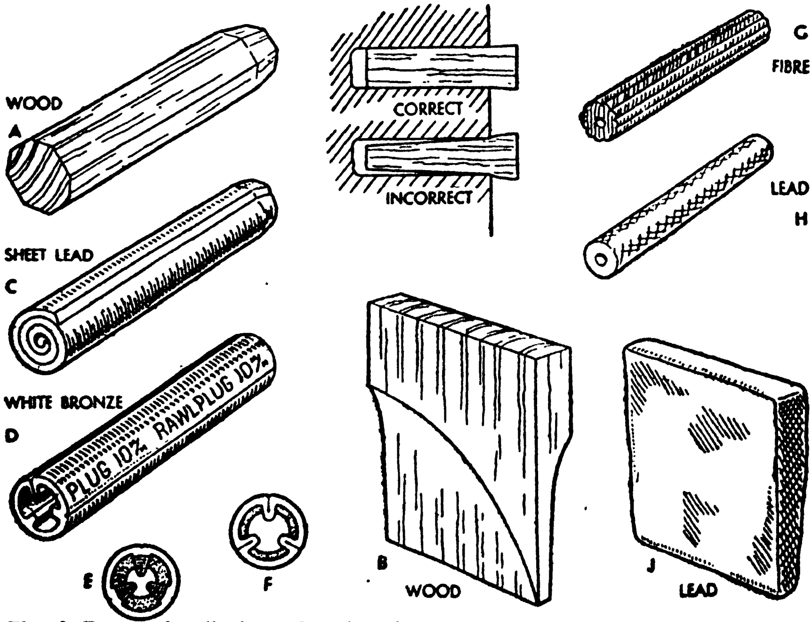


Fig. 6. Types of wall plugs. Circular plugs may be of wood, lead, hemp or soft metal. *A.* Octagonal (circular) wooden plug; *B.* wooden plug for brickwork joints; *C.* circular plug of sheet lead; *D.* white bronze wall Rawlplug with section (*F*) and one end coned (*E*); *G.* fibre Rawlplug; *H.* lead plug; *J.* lead wedge.

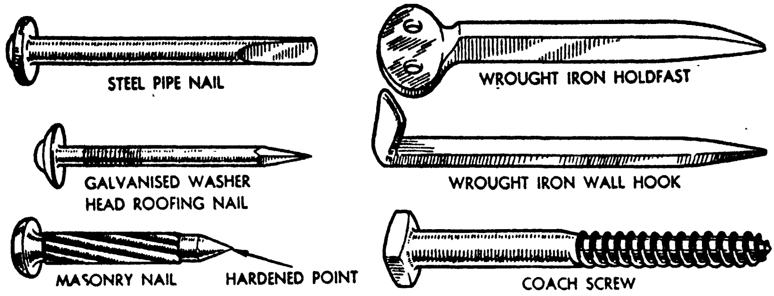


Fig. 7. Various types of common fastenings for use on external walls.

times it is necessary to fix a fairly wide member with screws, in which case they should be inserted slightly askew through the side of the material. For this purpose a pocket is cut with a gouge, as shown in Fig. 5 A, to allow the screw and the screwdriver to rotate freely. If the screw is to be inserted in the face of the work, it is better to drill a large shallow hole, so that the screw head can be covered with a pellet, as illustrated at Fig. 5 B and C.

Secret Screwing

In replacing a polished or varnished member, secret or slot screwing is sometimes employed to avoid damaging the surface with screw or nail holes. In this, the screws are partly driven into the main member with their heads projecting (Fig. 5 D). The heads are then coated with chalk, and the work to be fixed is pressed against the screw heads to transfer the chalk marks to the back of the woodwork. Slots are then cut downwards of width equal to the diameter of the screw shank, to meet holes cut for the heads of the screws, as shown at Fig. 5 E, and the woodwork is then fixed by forcing it into position over the screw heads.

Ill-driven screws or rusty screws are difficult to withdraw, and in repair work are often a source of annoyance. The corrosion of the metal binds the screw firmly in the wood, as the oxidation fills the surrounding cavities of the fibres. A tight screw may be loosened enough to unscrew by a sharp blow on the screwdriver when in the slot of the screw. Sometimes an effort to turn the screw further into the wood will help to loosen it, especially if the slot is burred by repeated attempts to withdraw the screw. Another way is to expand the metal by contact with a hot poker, so that when the screw contracts it will become loose and rotate freely.

Broken Screws

Screws with broken heads may be removed by filing a new slot across the top, or by gouging out the wood surrounding the head to give enough space for a good grip with the pliers. Generally, a long screwdriver is more efficient than a short one, but the end must fit the parallel slot of the screw head without too much play.

Coach screws (Fig. 7) are used for heavy work where screwdriver power is inadequate. Their heads are square or hexagonal, to be turned by means of a spanner.

As previously mentioned, to

insert nails or screws into a hard, brittle material such as a wall surface, plugs of softer material should be inserted to receive the fastenings. Fig. 6 shows several types of plugs used for this purpose. The position of the required fixing is first decided upon, then a hole is cut to suit the size and type of plug. Holes may be punched with a star drill or jumper, be drilled with either a hand or mechanical drill, or the mortar joints may be raked out with a plugging chisel.

In punching a hole for plugs, it is important to rotate the chisel slightly to prevent it jamming, and to use light, quick blows in preference to heavy blows, especially at the commencement of the cutting. Holes cut in this manner will be true and the wall will not be damaged.

Despite the number of patent plugging materials available, wood is still the predominant material for plugs. Wooden plugs should be of dry, straight-grained material, so cut that any shrinkage will not loosen the fixing. Circular plugs are generally roughly cut to an octagonal shape (Fig. 6 A), preferably with twisted faces, so that the stresses set up within the plug when driven counterbalance any reduction in size due to shrinkage. For a similar purpose, wedge-shaped plugs for mortar joints should be cut with twisted surfaces, as shown at B.

The success of a plug depends on a good fit in the wall; it should not be hammered tight on the face of the work, as this gives false security and tends to flake the facing material; rather should it fit hand-tight through most of the depth of the plug hole.

For external work, a plug should

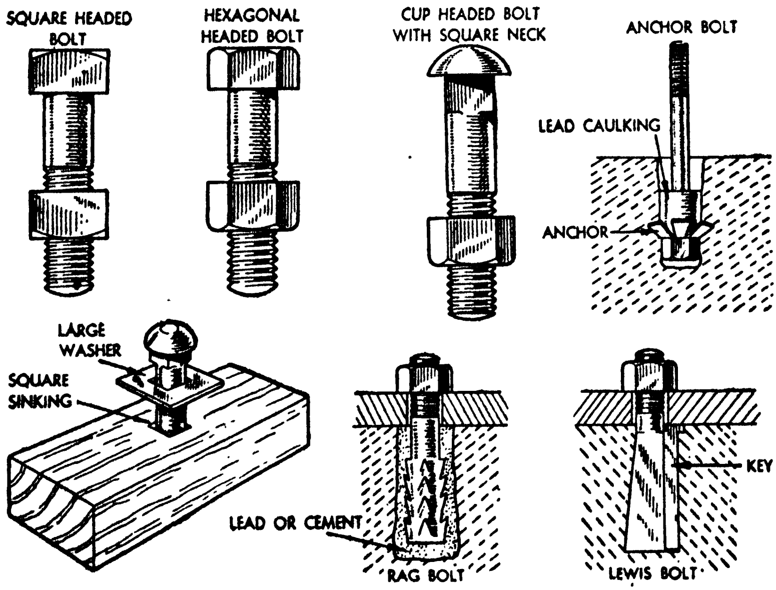


Fig. 8. Bolts for fixing purposes. Cup-headed bolts are frequently used for connecting timber together, as they are much less prominent on the face of the work.

be formed of sheet lead rolled and dressed into shape, or of the patent type (Fig. 6 C and D). This white bronze Rawlplug expands when the fastening is inserted, and grips throughout its entire length. The outside of the plug is scored to prevent any movement when the screw is inserted. The inner construction is made up of three flanges, which, when the screw is inserted, expand and cause the plug to grip the sides of the material into which it is fixed. At the same time, the screw cuts itself a thread in the metal. Note that one end (Fig. 6 E) is "coned", in order to facilitate the entrance of the screw when it is first inserted. These plugs are available in sizes from ½ to 2½ in. in length; with a coach screw they form a secure fixing for heavy work.

Internal Repairs

For internal work on finished surfaces, the fibre Rawlplug (Fig. 6 G), which is made complete with pilot hole from specially treated fibre, cannot be excelled. It provides a neat and inconspicuous fixing, which can be quickly inserted, with practically no damage to existing decoration or wall finish. Correctly sized tools, plugs and screws are the greatest assets of this system, which is most indispensable in building repair work. Other types of prepared plugs are made of lead tube and vulcanised rubber.

Fig. 7 illustrates a few types of external fastenings, which, with the exception of the masonry nail, hold better when driven into plugs. The masonry nail affords an efficient fastening to brick, concrete and other forms of building material. The nails have specially hardened points which enable them to be driven directly into mortar joints, breeze blocks and soft bricks in the same manner that ordinary nails are driven into wood. They are useful for fixing metal sheets, signs, pipes and brackets direct to walls.

As many building materials are brittle and liable to flake, pilot holes should be punched or drilled to receive the nails in hard material. These holes need not be larger than the diameter of the hardened point, nor deeper than two-thirds of the length of the nail used.

Masonry nails are obtainable from 1 to 2½ in. in length.

Use of Bolts

For stronger fixings, stouter fastenings must obviously be used. In this respect, bolts may be considered as a special form of screw, inasmuch as they draw together the parts being fastened. Their strength relies upon the resistance of the material bolted together, on the head of the bolt. For this reason, large washers should always be used with bolts which connect timber together, so as to give a greater bearing area. Bolts weaken the timber by severing the fibres, hence they need not necessarily form the strongest joint.

Ordinary bolts are of two main types, known as black and bright. The former are produced in a forging machine, and are left as forged, while the latter are usually turned from bright drawn mild steel bars. Bolts are screwed at one end with a standard Whitworth thread to receive a nut, which is usually hexagonal in shape. The diameter of bolts ranges from ⅛ in. by sixteenths of

an inch to 1 in., and from 1 in. by eighths of an inch to 3 in.

Bolt heads most frequently used are either square or hexagonal (Fig. 8). For connecting timber together, a cup head is often used because it is less prominent on the face of the work. To prevent rotation of the bolt while its nut is being tightened up, a square neck is provided, which is sunk into the wood, as shown. Holes for bolts should be drilled to the correct size of the shank with $\frac{1}{16}$ in. clearance.

For securing heavy work to concrete foundations, a rag bolt is largely used. Its form varies, and may consist of a rough bolt with the head splayed out and the body twisted, or the bolt may be tapered with its sides or corners gashed with a blacksmith's sett. To fix the bolt, it is suspended in a roughly cut, dovetail shaped hole, and the work to be fixed is placed in position, then a fine grout of sand and cement is poured into a runnel so as to encase the bolt. When the grout is set, the nut on the bolt can be finally adjusted. Instead of cement grout, lead may be employed, which must be well caulked when set.

For a temporary fixing, a Lewis bolt may be used. This has a tapering side which fits a corresponding tapering side of the hole, and is held in position by a key, as shown.

Another good fixing may be obtained by the anchor bolt (Fig. 8). The method of application is to prepare the hole with a punch or drill, place the bolt, head first, in position, and finally

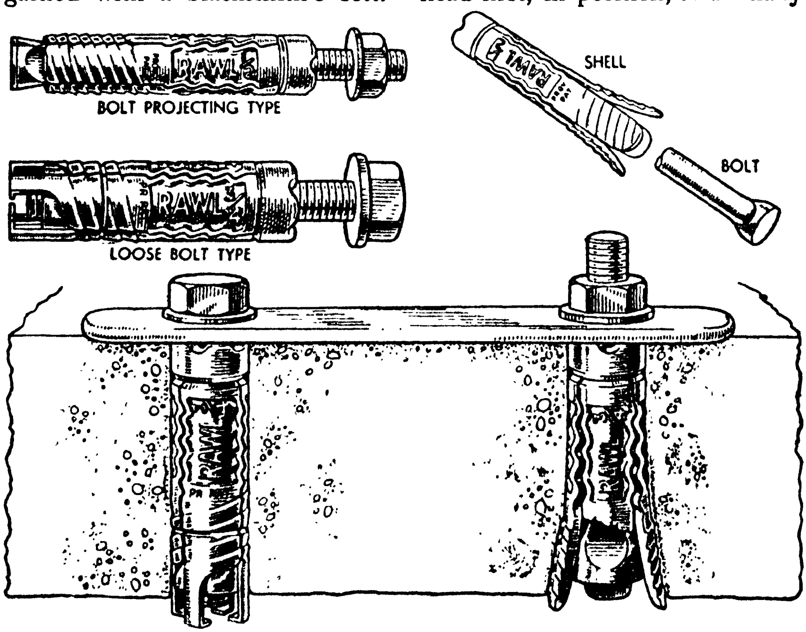


Fig. 9. Expansion bolts for fastening heavy work to stone or concrete. The bolt projecting type expands the shell when the nut is tightened. In the loose bolt type, the shell expands when the bolt is tightened. The latter type is useful in fixing heavy machinery which is difficult to lift over bolts.

the chilled iron anchor cone to which is attached a cylinder of lead. The cone is divided into segments, and shaped so that it can easily be slipped into position but cannot be withdrawn. Caulking is carried out in the usual manner, and the top portion filled with cement to minimise side strain. These bolts save considerable time in fixing, and are obtainable in sizes from $\frac{3}{8}$ to $1\frac{1}{4}$ in. diameter.

Expansion Bolts

Another quick and popular way of making a firm fixture is by means of an expansion bolt. These, as shown in Fig. 9, consist of a tubular metal shell divided lengthwise into four segments, the upper ends of which are held by an adjustable ferrule of steel. As the nut is tightened, the bolt is drawn through the shell, which firmly grips the sides of the hole.

There are two types of these bolts. Both work on the same fundamental principles. The only difference is that on one the expanding member is part of the bolt itself, and on the other it is detachable. With the bolt projecting type, the shell and the bolt are inserted into the hole together, while with the loose-bolt type the shell and expanding member are inserted in the hole and the bolt screwed in to tighten. The latter type is specially valuable where it is difficult to lift heavy machinery over the bolt. Both types are available in sizes from $\frac{1}{4}$ to $\frac{3}{4}$ in. diameter.

When a building is being erected, and during alterations or structural repairs, it is usual to build special fixing blocks into the structure itself. Fig. 10 shows the general arrangement of a doorway opening, with the positions of the fixing blocks for the door jamb and skirting board. The blocks are made of cement and coke breeze (1 to 6) to the same size as a standard brick.

In repairing joinery which has been nailed to breeze, no attempt should be made to withdraw a stubborn nail. Its head should be pulled through the wood and then broken off or flattened against the wall. Nails driven into breeze quickly rust, and become so firmly embedded that attempts to withdraw will flake the surface of the wall.

An alternative fixing is obtained by building thin wooden pallets into the brickwork joints (Fig. 10 C). Wood bricks or nogs should not be used, as they are liable to shrink and become loose when the green walls dry out.

Walls formed of partition blocks rarely exceed 3 in. in thickness, and, as they are generally hollow, are not very suitable for fixings. Some partition slabs will hold nails and screws, and thus support light finishings. A good way with harder blocks is to insert a bolt, with large washers, through the wall (Fig. 10 D). Where heavier weights have to be supported by the wall, the bolts should be supplemented by long metal straps or plates instead of washers, so as to distribute the weight over a greater area.

During construction of concrete work, bolts, sheet-metal cramps, wires or wood blocks should be embedded in the surface to provide a fixing agency, as shown in Fig. 11. Failing this, the work must be drilled for the insertion of plugs or expansion bolts.

Some miscellaneous fastenings

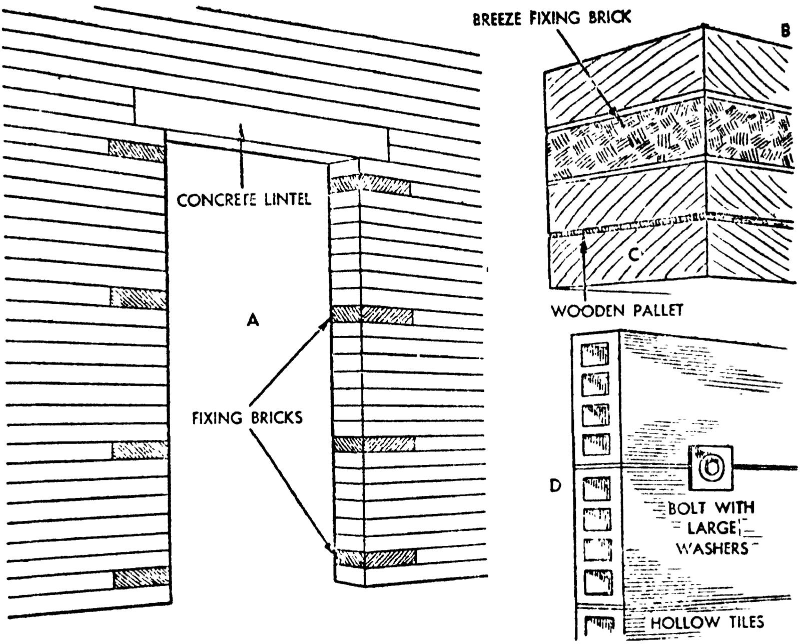


Fig. 10. *A.* Arrangement of fixing blocks around a doorway opening; *B.* breeze fixing block; *C.* wooden pallet in joint; *D.* bolts through "pot" wall.

applicable to wood are shown in Fig. 12. Dogs are made of square or round iron from 2 to 12 in. and over in length. Their pointed ends are formed at an angle slightly greater than 90 deg., so that when driven into the timber they tend to draw the parts together. Dogs are used for temporary work.

Corrugated Joint Fasteners

Corrugated metal "saw-edge" joint fasteners are for permanent connections between light members. They may be driven with a hammer either across the face or edge of the joint. The corrugations are slightly tapered, to draw the joint together, and, when driven, interlock with the wood and hold the members firm. These joint fasteners are obtainable from ¼ in. by eighths of an inch to 1 in., as units or in the form of a coil.

Glass or ear plates (Fig. 12) are used to hold light framings to walls. They are screwed to the back of the frame and to the face of the wall. The slot screw plate may be used as a glass plate, or it may be housed into the back of the work for a secret fastening. The large hole is to take the head of a screw, and the slot is to engage the shank.

An important secret fixing for lengthening timbers in joinery is the handrail bolt (Fig. 12). The bolt has a thread at each end, a square nut at one end, and at the other a circular nut with slots on the edge. The pieces to be jointed are marked with a templet; holes are bored for the bolt and mortises cut for the nuts. The square nut is inserted in one mortise and the

bolt screwed up. The circular nut is then dropped in the mortise on the other member, the bolt inserted, and the nut tightened by a screwdriver or handrail punch until the joints fit closely together. For smaller work not subject to excessive stress, the double-ended dowel screw (Fig. 12) is sometimes used, but it is very weak, however, in end grain.

Permanent Fastenings

To make permanent fastenings in sheet metal, or for jointing two thicknesses of sheet metal together, hardened self-tapping screws, as shown in Fig. 13, are a great asset. They form an ideal fastening in heating and ventilating work, for connecting ducts and flues in air-conditioning systems, radiator enclosures, roofs, refrigerators and hollow metal windows. Holes are punched or drilled into the material to be fixed, and the hardened screws cut their own thread as they are screwed in.

Types A and B are for use in thin sheet metal not heavier than 18 gauge. Holes are better if merely pierced through the metal so as to leave a burr which provides a greater surface for the screw to engage, as shown at B and D. A hardened hammer-drive screw C forms a permanent fastening to iron, brass, aluminium casting, steel, bakelite or material of casein composition.

For sheet metal up to 6 gauge, the types shown at D, E and F are recommended. Self-tapping screws are obtainable in sizes from $\frac{1}{8}$ to 2 in. in length.

For joinery work, adhesives may be divided into five main groups: (1) Animal glue produced in dry

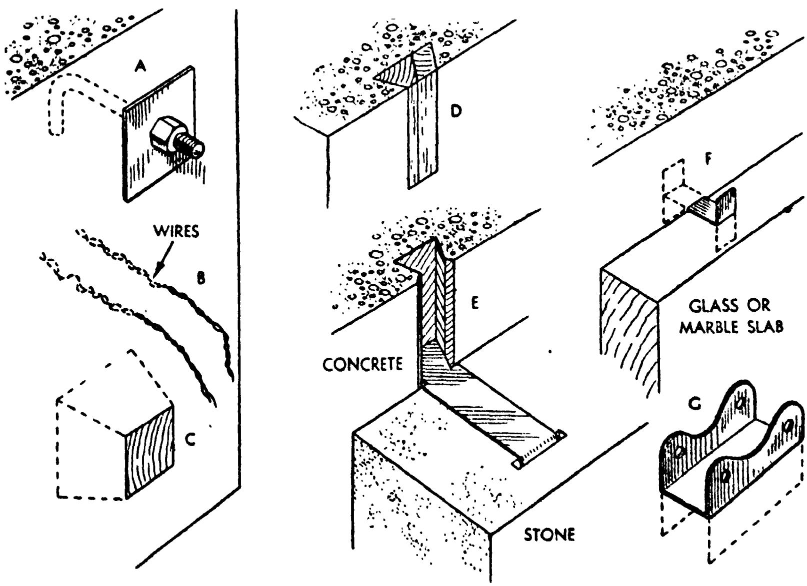


Fig. 11. Methods of arranging fastenings to concrete. *A.* Bolt built in wall during casting; *B.* wires used to hold shuttering may be used as fixing agency; *C.* dovetailed wood block; *D.* dovetailed strips in chase; *E.* patent dovetailed slot and anchor for stone facing; *F.* bronze cramp for marble facing; *G.* clips for joists.

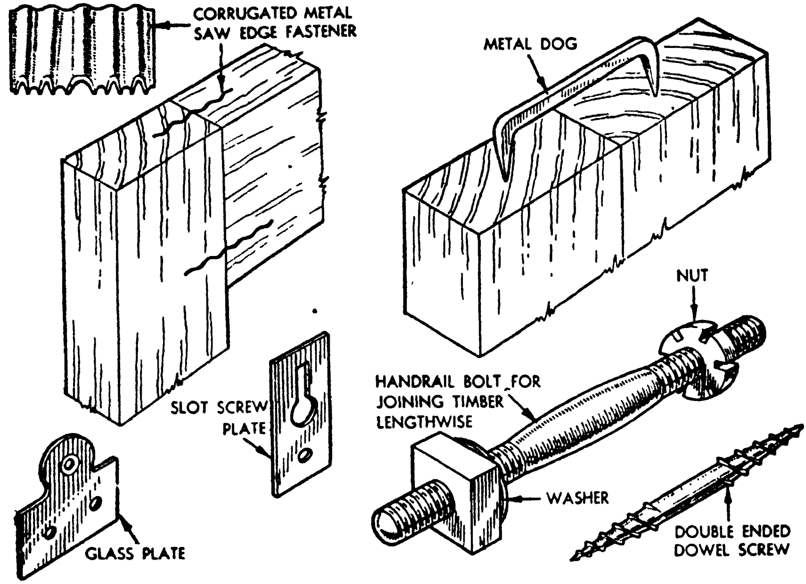


Fig. 12. Miscellaneous fastenings to wood. The corrugated metal saw-edge joint fasteners are for permanent connections between light members.

form, which, with the addition of water, is melted and applied hot; (2) liquid or jelly glue, which is supplied in a form ready for immediate use; (3) blood albumen, which, since it is liable to deteriorate rapidly, must be mixed from separate ingredients prior to use; (4) casein or cold-water glue; and (5) synthetic resins.

Preparation of Glue

Cake glue is prepared from either skin or bone material, and is supplied in the form of cakes, pieces, granules or powder. Hot, freshly made glue should not have an unpleasant smell, and a well-made joint should withstand a stress of 1,000 lbs. per sq. in.

While the manufacture of skin or hide glue differs from that of bone glue, the procedure in preparing the glue for use is the same. The best glue may be spoiled by improper methods of preparation.

Glue should always be soaked in clean water before melting, in order to get back into the glue the moisture it originally contained. The method is to break the cakes into small pieces in a cloth or sacking, to prevent the pieces flying, and to soak them in cold water in a non-corrosive vessel for twelve hours or more, according to the sizes of the pieces. As a rule, the glue is allowed to soak overnight.

Soaked glue is placed in the container of the glue heater and melted by the heating of the water in the outer jacket. Glue should not be overheated by allowing the outer vessel to become dry, as overheating reduces the adhesive strength and results in a gradual deterioration of the glue. On the other hand, underheated glue lacks penetration power, and soon

chills. A temperature between 120 deg. Fah. and 150 deg. Fah. gives the best results.

The white scum or crust which forms on the top of glue should be removed as waste. This scum is due to the surface of the glue solidifying owing to the difference in temperature of the glue solution and the surrounding air.

Blood albumen glue is a mixture of dried blood to which specific chemicals are added immediately before use; because of this its use is practically confined to the gluing of plywoods.

Casein glue is obtainable in the form of a fine powder, which is added to cold water to form a pasty fluid. It is very convenient to use, and is practically waterproof and heatproof. Casein is produced from milk and the soya bean. It is ground to a powder and mixed with chemicals, which are necessary in order to dissolve the casein, which is insoluble in water.

When preparing the glue, the powder should be well stirred, as the chemical content is heavier than the casein and is liable to settle at the bottom. A measure of the powder is added to an equal measure of cold water and stirred until the water is absorbed.

Synthetic resins require greater accuracy in preparation, but they are tending to become simpler to use. Many patent resin adhesives are available in the form of thin sheets of impregnated tissue paper, finely ground powder or as an emulsion. For joinery work to be repaired, the urea-formaldehyde type in liquid form is most convenient. The cement is applied to one surface of the joint, and a liquid or powder hardener to the other. Setting action does not commence until the two surfaces are in contact with one another. Resin adhesives are waterproof and fungus proof, and it is noticeable that a great number of tested glued joints fail in the wood fibre but very seldom in the adhesive.

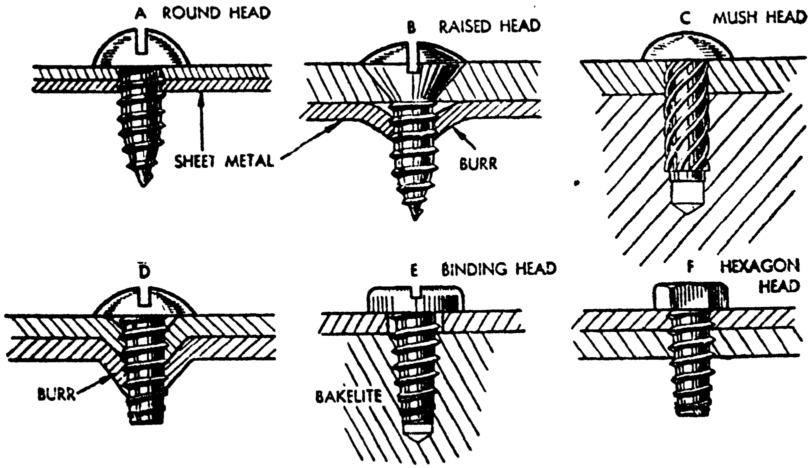


Fig. 13. Self-tapping screws for fixing sheet metal to metal and bakelite. A and B. Jointing sheet metal and making fastenings to sheet metal up to 18 gauge; C. hammer-drive hardened screw for jointing sheet metal to casting. The pilot holes are punched or drilled; D, E and F. screw drive self tapping.

CHAPTER 6

PLUMBING AND GLAZING

WATER SUPPLY. OVERFLOW. DOWNSERVICE PIPES. STORAGE CISTERNS. SELECTION OF BALL VALVES. REPAIRING A BALL VALVE. HOT-WATER SUPPLY. TYPICAL FAULTS. ARRANGEMENT OF PIPES. SIMPLE CYLINDER SYSTEMS. PRINCIPAL COMPONENTS. CALCULATION OF BOILER SIZES. FURRING: CAUSE AND REMEDY. STORAGE VESSELS. SECONDARY CIRCULATION. BOOSTING. PREVENTION AND TREATMENT OF FROZEN PIPES. GLAZING. TOOLS REQUIRED. MEASURING UP. HACKING OUT. APPLYING PUTTY. SHAPED GLASS. RE-GLAZING METAL FRAMES. REPAIRS TO LEADED LIGHTS. SOLDERING.

THE plumber's work is primarily concerned with the supply of water, and before installing the water supply in a house or other building the arrangement and position of fittings have to be considered. Generally the shortest route between the water company's main and the building is the most desirable, but local conditions may require otherwise. For example, it may be more convenient to make the connection to a building at the side, or rear, according to the required points of supply and the position of sanitary fittings. It may or may not be desirable to run a supply pipe through the building.

Company's Main

The water company's main under the pavement or road is of cast iron, and the connection to this main for a supply to a building is normally made by drilling and tapping the main and inserting a brass or gunmetal screw-down stop ferrule. This ferrule is actually a right-angled stop valve which can afterwards be used by the company if required for shutting down purposes (Fig. 1). No access is provided to this valve except by excavation.

Lead pipe is mostly specified for connection to this ferrule and as the supply pipe to the building, but in some districts wrought iron and copper pipe are permissible. The connection to the cast-iron main and the pipe from the main to the stop valve just inside the boundary of the premises in the London area are the responsibility of the water company as far as repairs are concerned.

The main service from the company's cast-iron main, and in fact any pipe below ground, should be at least 2 ft. 6 in. underground and laid with a slight fall back to the cast-iron main. A stop valve should be fitted to this pipe just outside the boundary of the premises (Fig. 1). Again in the London area this stop valve is the property of the water company and may only be used by them.

A further stop valve should be fitted just inside the premises in a suitable position accessible for use of the occupier or others controlling the water supply (Fig. 1). This

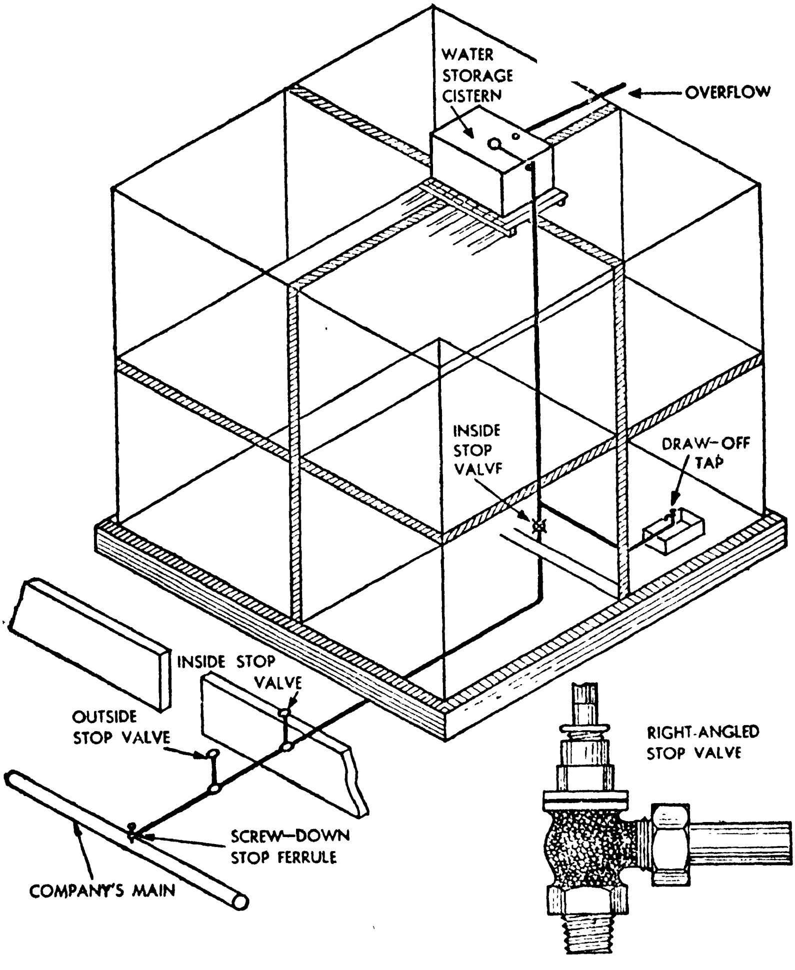


Fig. 1. Isometric view showing arrangements of main cold-water supply to building. Connection of main water service pipe to storage cistern is made by means of a brass cap and lining soldered to the lead pipe and connected to the ball valve. The overflow should be large enough to permit the escape of water from the cistern in the event of the ball valve becoming defective.

last mentioned stop valve becomes the water control to the building, and it is essential that it be kept in good order and repair.

It is important, too, that a responsible person or persons, or in the case of a dwelling-house the whole family, should know the exact position of this stop valve, what it is, and how to use it.

A draw-off tap (Fig. 1) should be fitted on the premises side of this stop valve for the sole purpose of emptying or draining the main pipe beyond, when the water is shut off by the stop valve. The

purpose of this draining tap is to facilitate repairs or for emptying the pipe in time of frost. In dwelling-houses this draw-off usually serves as a dietetic and drinking-water supply situated over the kitchen sink. If, however, a long run of pipe should precede this, between the point of entry to the building and the sink, a draw-off should be provided near the stop valve.

The main service pipe, from its point of entry into the building, should be taken the nearest and most direct way to the storage cistern, compatible with frost-preventing arrangements, as explained fully later in this chapter.

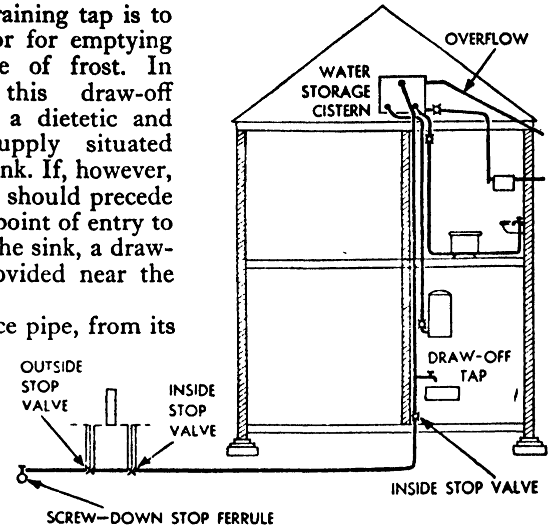


Fig. 1a. Section showing a typical arrangement of the ordinary domestic cold water services.

The whole length of the pipe should be laid and fixed in such a manner that will enable it to be completely emptied when the water is turned off.

Draw-offs for dietetic and drinking purposes are essential, as no drinking-water supply should be taken from a storage cistern. The connection of the main water service pipe to the storage cistern (Fig. 1) is important. It should be made by means of a brass cap and lining soldered to the lead pipe by means of a wiped soldered joint, and connected to the ball valve that is fixed through the side of the cistern. In no circumstances should the ball valve be slung over the top edge of the cistern and hang unsupported over the water; it should be fixed through the side of the cistern with a back nut and washer.

It is important that the overflow (Fig. 1) be large enough to permit the escape of water from the cistern, should the ball valve become defective.

In calculating the size of the overflow pipe an internal diameter of at least two sizes larger than the main inlet pipe should be adopted. This means that with a main supply of $\frac{1}{2}$ in. an overflow pipe of 1 in. diameter should be fixed, and similarly with a $\frac{3}{4}$-in. supply a $1\frac{1}{4}$-in. overflow. It should be noted that an overflow pipe is a "warning" pipe, and the outlet should be so fixed that an overflow of water from the pipe would immediately be apparent.

Downservice pipes from the storage cistern to fittings should not be restricted in size or diameter. The amount of water to be delivered to each fitting must be considered, together with the number of fittings from which water might be drawn at one time. The size of the fitting

should help in determining the size of the supply pipe to it. For instance, it will serve no useful purpose to provide a ¾-in. pipe to a ½-in. fitting. Lavatory wash basins and waste-water preventers are usually provided with ½-in. valves, so that the supply pipe to these fittings need only be ½ in. If, however, several fittings are to be supplied from one downservice pipe, the above remarks apply only to the branch pipes. Fig. 1A shows a typical arrangement of cold water services.

The downservice pipes should be controlled at the point of connection to the storage cistern by means of a suitable screwdown stop cock (Fig. 2). It is also good practice to control branches to fittings in the same manner, to facilitate repairs, and thereby obviate other parts of the system being shut off at the same time.

The cold-water supply pipe to the domestic hot-water system must be entirely separate from any other service, and a separate connection for this pipe must be made to the cold-water storage cistern. The controlling stop valve to the downservice pipe is usually situated, and connected to the pipe, in a position in close proximity to the hot-water storage vessel.

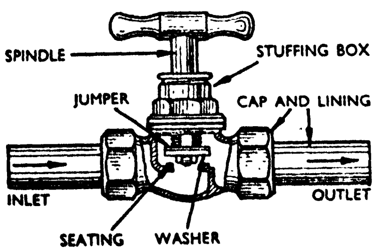


Fig. 2. Screwdown stop cock for controlling downservice pipes at point of connection to storage cistern. Branches to fittings should be controlled in a similar manner to facilitate repairs.

The size of the cold-water storage cistern must be compatible with the supply to the number of fittings on both hot- and cold-water supply systems and the maximum demand on the fittings. A safe rule is to allow a storage of 30 gallons per person with a minimum storage of 50 gallons. In the London area the Metropolitan Water Board demand a storage of 80 gallons minimum in cases where a domestic hot-water system is installed.

It should be noted that the total capacity of a storage cistern is the amount of water it will hold when filled to the top. In actual practice, however, the water line will be from 4 to 6 in. below this, so that the loss in capacity through this difference must be allowed for when ordering.

Valve Pressure

The ball valve to the storage cistern should be of the high-pressure type, but may be of Portsmouth or Croydon pattern. If provided with a silencing tube, the latter must be perforated at its point of connection with the valve, in order to prevent siphonic action being set up should the main supply pipe be drained for any purpose. Ball valves to water-waste preventers should be high- or low-pressure valves, according to the pressure, or head, of water at the valve. The head of water can be ascertained by taking in a vertical line the distance between the water level in the storage cistern and the point of delivery of the ball valve (Fig. 3). If this vertical distance, without taking into consideration the run of pipe, is 10 ft., then there is a 10-ft. head of water on the ball valve, and this is a factor that must be considered

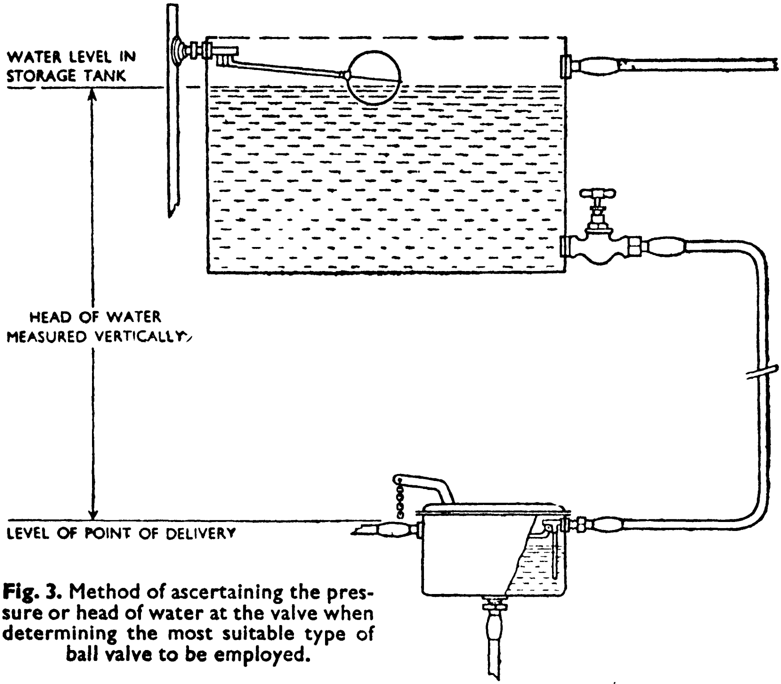


Fig. 3. Method of ascertaining the pressure or head of water at the valve when determining the most suitable type of ball valve to be employed.

when deciding the type of valve. The following Table is given as a guide.

Head of Water in ft.	*Type of Ball Valve.*
Up to 6 or 8 ft.	Fullway.
Between 8 and 15 ft.	Low pressure.
Over 15 ft.	High pressure.

A ball valve, without the addition of a silencing pipe, consists of five parts: the body, jumper, stem, split pin and ball. The ball is constructed of copper, and the remainder of gunmetal or brass. The jumper, consisting of body and screwed top, holds a washer which closes with the valve against a seating in the body of the valve. Insertion rubber is mainly used, and it is a simple operation to renew this washer. In the case of the ball valve to a storage cistern, it is rarely necessary to remove the valve to renew the washer, but in the case of the valve to a water-waste preventer this measure should be taken.

The purpose of a ball valve is to control the water supply to a storage, flushing or automatic flushing cistern, and the principle of all types of ball valves is that a ball floating on the surface of the water raises or lowers a lever, which actuates a jumper or piston that opens or closes, as the case may be, on to the seating of an aperture through the body of the valve.

The four main types of ball valve are "Portsmouth", "Croydon", "Equilibrium" and "Reverse action". The Portsmouth pattern (Fig. 4), used mainly for flushing cisterns or water-waste preventers, has a piston which works horizontally in the body of

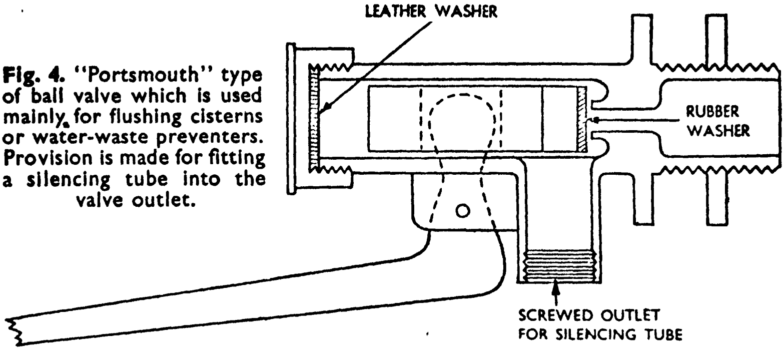
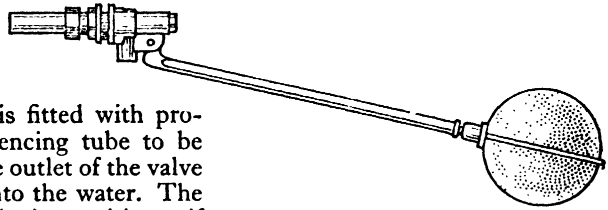


Fig. 4. "Portsmouth" type of ball valve which is used mainly for flushing cisterns or water-waste preventers. Provision is made for fitting a silencing tube into the valve outlet.



the valve, and is fitted with provision for a silencing tube to be screwed into the outlet of the valve and extended into the water. The object of this tube is to mitigate, if not prevent, the noise of the water running into the cistern. The Croydon-type valve (Fig. 5) is usually employed for the connection of main water supply to a cold-water storage cistern. It is essentially a high-pressure type valve with a vertical piston.

All ball valves should have a brass or gunmetal body and piston, brass or copper stem, and a copper ball. There are various types of ball, the most common of which is made in two halves, which are joined by means of a soldered seam. Trouble is often experienced with this type of copper ball owing to the failure of the soldered seam due to electrolytic action, particularly where the ball is in contact with soft water. There are other types of ball on the market designed to prevent this trouble, but as a precaution against the occurrence it is useful to paint the seam before fitting. A better method is to join the halves of the valve by sif-bronze welding.

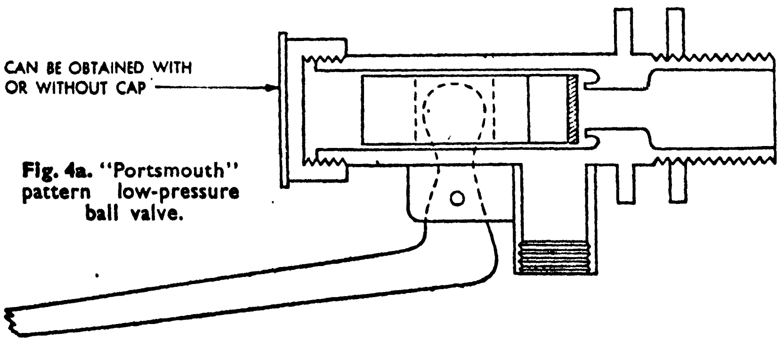


Fig. 4a. "Portsmouth" pattern low-pressure ball valve.

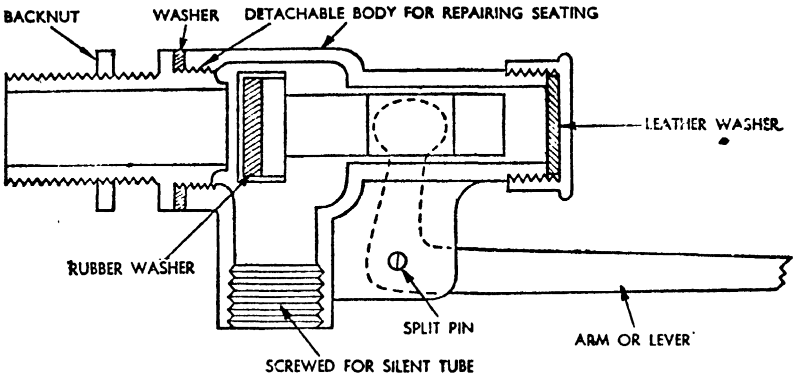


Fig. 4b. Full-way valve which closes against a pressure of 10 lb. per sq. in.

Ball valves are constructed for varying pressures of water, and accordingly are specified as "high-pressure", "low-pressure" and "full way". (Figs. 4, 4A, 4B, and 5). In this connection the Metropolitan Water Board specify the following pressure tests which denote their suitability for varying pressures and according to which the valve must be stamped H.P., L.P. or F.W. "Every high-pressure ball valve shall close against a pressure of 200 lbs per square inch.; low-pressure 50 lbs. per square inch; full way 10 lbs. per square inch."

The essential difference in construction is merely in the diameter of the orifice through which the water flows. A high-pressure valve has a small orifice, and it will be realised that water at a high pressure is more controllable when passed through a small aperture, and at the same time will pass through more quickly than would water at a low pressure. On the other hand, water at a high pressure passing through a low-pressure valve has a larger area of valve against which to exert its pressure, and which would require a greater force of reaction in the shape of a longer stem and larger ball.

Therefore a high-pressure valve should be used on main water supplies and downservices with a considerable head or height; low-pressure valves where there is a head of less than 15 ft.; and a fullway valve where the head is less than 6 or 8 ft.

Repairing Ball Valves

To repair a ball valve, it is better first to remove the whole valve from the cistern and dismantle by taking out the split pin holding the stem to the body and keeping the piston or jumper in position. Screw off the head of the piston, take out the worn washer, cut and fit new washer of *insertion* rubber. Pure rubber used for this purpose usually swells when in use, which will probably involve returning to the job for regulating. The thickness of rubber in insertion being less, the expansion is less. Clean the jumper and working parts of the body with emery paper to remove any lime deposit or incrustation; see that the jumper works freely in the body of the valve; and try the end of the stem and all working parts. Examine

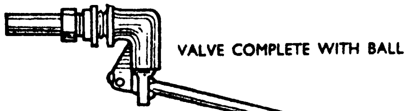
the seating of the valve, and if worn or pitted, reseat with re-seating tool. Smear with tallow on the working parts and re-assemble. After refixing the valve in the cistern, always regulate or adjust properly for water level.

A ball valve should allow a flushing cistern to fill within two minutes. If it does not do this, first examine the rubber washer, as it may be swollen. The aperture must be clear and the pressure unobstructed. If all these points are as they should be, and still the cistern does not fill in the required time, fit a ball valve for a lower pressure, i.e., with a larger aperture. Alternatively, if the cistern fills in the required time but does not shut off in spite of a new washer or reseating, most probably a higher-pressure valve is required.

The equilibrium ball valve (see Fig. 6) is used in cases of severe water hammer, particularly where the trouble is due to a very high pressure of water. The principle of the valve is incorporated in the type of piston, the piston being designed so that the pressure of water is exerted equally on both of its ends. By this means the piston is not pushed down, and therefore the ball remains steady, and its buoyancy is not affected.

The reverse-action ball valve is used in automatic flushing cisterns. The simple principle is that when the ball drops, the valve closes instead of opening. The valve can usually be adjusted so that the merest trickle of water passes through when the ball is down. It will thus be seen that a slow-filling action is obtained, gradually increasing as the cistern or tank fills.

This action is eminently suitable for flushing cisterns for urinals where a slow periodic automatic flush is required.



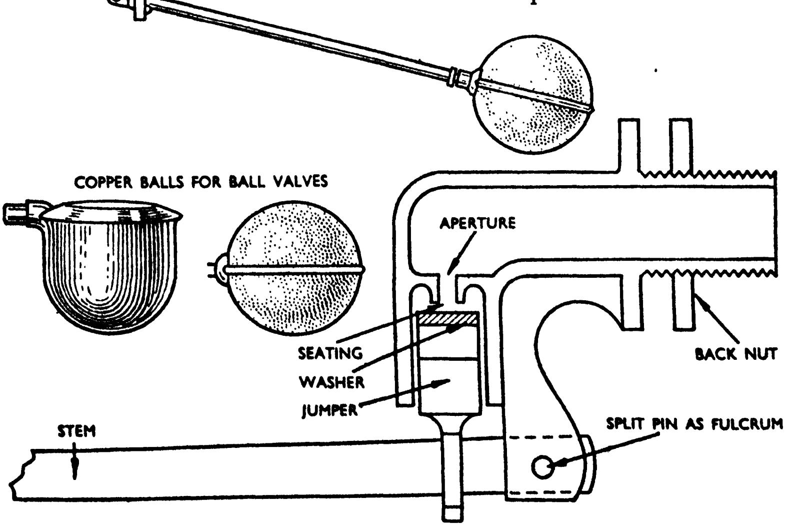


Fig. 5. "Croydon" type high-pressure ball valve. This type is generally used for the connection of main water supply to a cold-water storage cistern.

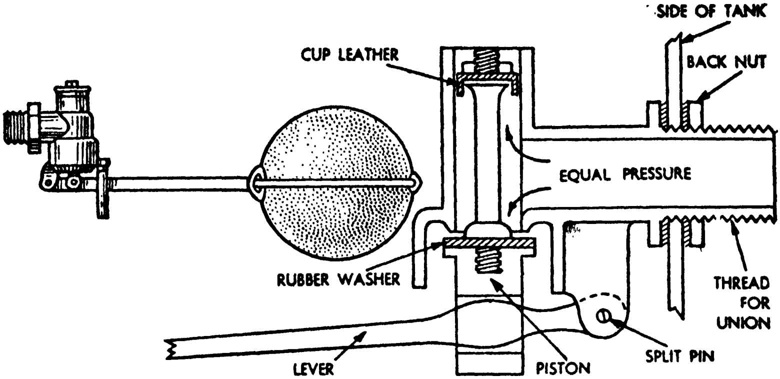


Fig. 6. Equilibrium ball valve. The piston is designed so that the pressure of water is exerted evenly on both ends of the valve.

A large majority of modern valves and taps, whether used to control water services or the water at the appliance to which the water is delivered, are of the screw-down variety. Plug, spring and other types of quick-closing valves are, of course, still in existence, and have to be dealt with in general repair work.

The principle of the screw-down valve (Fig. 6A) is that a spindle, on the end of which is a washer, is screwed down until the washer engages on to a brass seating. It will be realised that the seating has to be smooth, and the washer suitable for the purpose for which the tap or valve is to be used—*i.e.*, hot or cold water. Generally speaking, a leather washer is used for cold-water, and rubber for hot-water washers.

Renewal of Washers

All types of washers wear with constant use and have to be replaced. The operation of re-washering a tap consists in removing the top of the tap by unscrewing it from the body, taking out the jumper, removing the old and worn washer, and replacing it with a new one. The washer should be the same diameter as the jumper, and be secured to the jumper by means of a small nut. It should be remembered that seatings wear and become pitted and rough, and are often the cause either of constant re-washering or a tap that is still leaking even after re-washering. The seating should, therefore, be examined, and, if rough or pitted, be reseated with a reseating tool. During the operation of re-washering, the washer between the body and the top of the tap or valve must be replaced.

Leaking Valves

Frequently a valve is found to be leaking between the spindle and the gland of the tap. The purpose of the gland is to make a joint between the spindle and the top of the valve, and to enable it to be screwed down without leaking. The gland is packed with asbestos string or other suitable similar packing, and it screws down into the top of the valve, exerting a pressure between the spindle and the packing. A tightening of this gland may stop the water

oozing through, but if it has been screwed down to the end of its thread, new packing should be inserted.

Plug cocks (Fig. 7) are often a source of trouble, and are not really suitable for positions where a tap is to receive constant use. They are used quite a lot as emptying cocks on hot-water and heating systems. Causes of leakage in plug cocks are the wear of both plug and socket, pitting due to the presence of a foreign matter between the plug and socket, and the forcing down of the plug into the socket or body of the cock to stop dripping. The result of the latter misuse is to force the socket open so as to render an inaccurate fit between the two. A worn or pitted plug cock can be "ground in" by smearing a grinding-in paste on the plug and turning in a circular motion, similar to the operation involved in grinding-in a car valve.

Valves for use on hot-water and heating systems are, or should be, of the gate type (Fig. 8), in which the two-faced seatings of a gate are screwed down into the body of the valve to shut on to the respective seatings at the inlet and outlet. The seatings wear through use and become distorted through misuse in forcing down too hard. Particles of rust and fur become jammed between the seatings, and cause the seatings to wear. For repair the removal of the valve for regrinding is necessary, or the provision of a new valve.

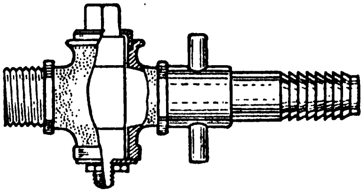


Fig. 7. Common type of plug cock.

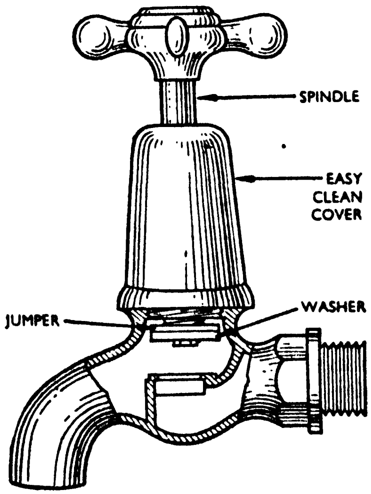


Fig. 6a. Screwdown valve. The spindle is screwed down until the washer at the end engages on the brass seating.

Water Hammer

Water hammer in a cold-water supply system or service pipe is produced by concussion, or the concussive effect, caused by the quick shutting of a tap or ball valve transmitting a shock or rebound through the water in the pipes. When water is flowing through a tap or stop valve, and the tap is quickly shut, the concussion of the water on the jumper or washer will cause the shock to rebound through the pipe. The line of least resistance to this shock is usually the jumper of a ball valve on the system, or another loose-jumpered or badly washered tap, which is pushed out by the pressure of the rebound travelling through the water. This pushing out of the jumper causes the ball of the valve to bounce on the water and to start the valve reverberating or chattering, which is the noise referred to as water hammer.

Water hammer may have a very serious effect on the piping system, particularly if lead pipe is used. Bursts may occur due to fatigue, especially if the pipe is old and weak.

If the water hammer cannot be cured by attention to taps and washers, it may be desirable to instal an air vessel (Fig. 9), a dead end, as it were, of a larger bore or the same bore pipe, so that the concussion may be taken up by compressing the air in the vessel. It may also be remedied by fitting an equilibrium ball valve, in which the shock or pressure would be exerted equally on each end of the piston and obviate the movement of the ball.

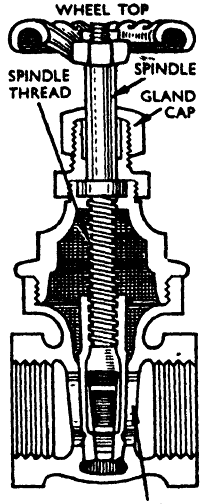


Fig. 8. Gate type valve for use in hot-water and heating systems.

Frozen pipes and frost-bursts can be prevented, either by precautions taken when fixing the pipes or during periods of frost. Pipes burst when the contained water freezes, because in the process of turning to ice a gradual expansion takes place until it reaches a maximum of about 8 per cent. It is this expansion which causes the walls of pipes and vessels to burst or break.

It will readily be seen that whatever the type of metal, unless its tensile strength will withstand the expansion, failure will occur and a fracture will result. Pipes of lead and wrought iron will readily burst under the expansion. Copper tubes have a greater tensile strength, but will also fracture when placed in exposed positions during periods of severe frost.

The simple remedy against frost-bursts is to take precautions to prevent the water freezing. Protection is the main precaution, but in all cases the removal of the contained water from the pipes, especially those in exposed positions, is essential. To facilitate the removal it is important that pipes should be fixed with a fall towards the position from which the pipe can be drained, so that when the water is turned off at a stop cock, and a draining tap is opened, the water in the pipe will drain out.

It should be remembered that unless both ends of the pipe are opened the contained water cannot be released, so that if a ball valve or tap is fixed at the upper end of a main water pipe, it must be opened as well as the draining tap. To open a ball valve, particularly the one in a cold-water storage cistern, it will be necessary to reduce the level of the water in the cistern by opening a tap on the downservice from the cistern. In the case of the ball valve in a waste-water preventer, it will be necessary to cause the water to flush. This is often overlooked, particularly by the householder who imagines that all he has to do is to turn off the water at the main stop cock and open the draining cock.

The best protection against freezing is to prevent the contained water in pipes and vessels from reaching freezing point. In other words, to prevent the pipe

or vessel losing heat and reaching the same temperature as the surrounding air.

An idea of the amount of heat lost by water in freezing will be obtained when one realises that even after being reduced to freezing point (32 deg. Fah.) the water must lose 142 British Thermal Units in turning to ice at the same temperature. The heat so given off is called the latent, or hidden, heat of ice. This is, of course, in addition to the heat lost by the water in the temperature drop from its normal temperature to 32 deg.

As already stated, pipes laid underground should be 2 ft. 6 in. deep, and even in this position, if there is any risk of freezing, extra precaution should be taken by providing a wooden casing with felt or other similar material as packing around the pipe. The casing should be properly protected against rot with some suitable coating.

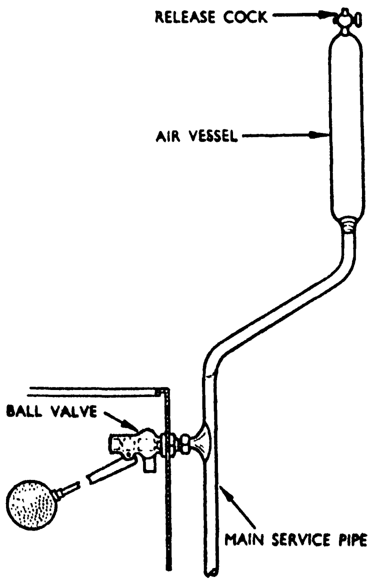


Fig. 9. Water hammer may be cured by installing an air vessel, which takes up the concussion by compressing the air.

Pipes above ground should not be fixed externally unless absolutely essential. If so, protection must be given by means of a casing around the pipe, the casing being filled with a suitable insulating or heat-conserving material such as felt. Provisions for emptying and means of control are also essential.

Internally pipes should be fixed if possible on internal partitions or walls, rather than on the inside of the colder external wall. The temperature is not likely to be so low on internal walls, particularly in an occupied building. If the building is entirely unheated, or if the pipes must be fixed in positions subject to frost, they should be suitably protected. The type of casing will depend on the type of building.

Casings and Fillings

Generally speaking a wooden casing, fitted with a part which can easily be removed for access to the pipe without damage to the surrounding walls or ceiling, is the most economical in the long run. Fillings for casings may consist of sawdust, cork or felt or similar material that is heat-conserving on account of the contained air spaces. The use of hair felt alone is satisfactory, provided that it is spirally wound and overlapped around the pipe and properly secured.

It is the writer's experience that canvas-backed hair felt usually fails, either on account of an insecure binding or as a result of being re-fixed unsatisfactorily after its removal for any purpose.

Pipes in roof spaces should always be protected with casing

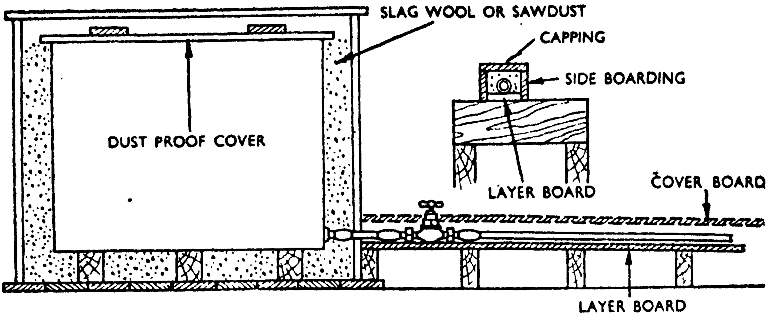


Fig. 10. Method of protecting pipes and storage cisterns in roof spaces. Casings are easily built up and may be filled with slag wool or sawdust.

and packing (Fig. 10). If the pipes are laid on boarding with suitable falls, it is a comparatively easy matter to build up a casing that can be suitably filled. It has been found in the past that the most vulnerable position from the point of view of freezing is where the pipe passes from the upper room through the ceiling close to the eaves into the roof space.

If, however, the pipes are carried up on the internal walls, this will not apply. Existing pipes in this position that are likely to give trouble should either be removed and carried up in a different position, or else suitably protected. A boarded roof is, of course, a measure of protection against frost in roof spaces.

Protection of Cisterns

Storage cisterns in roof spaces should be protected at the sides by means of a casing filled with sawdust or slag wool to a thickness of 4 in. (Fig. 10). In addition, a proper dust-tight cover should be provided. In cases where stop cocks are provided to the down services the protection of the stop cock, if fixed in the roof space, should not be overlooked. A labelled removable casing is an excellent precaution. There is no doubt that the best position for a cold-water storage tank or cistern is in a properly constructed cistern room, whether in the roof space or not. The cistern can then be fixed in a hygienic, properly lighted and ventilated position readily accessible for repair work or inspection.

Hot-water Supply

The efficient supply of hot water for domestic purposes to a house or building is dependent on a number of circumstances. It is not sufficient to provide a boiler, piping and storage arrangements without having regard to the first principles of hot-water supply, the maximum quantity required, and the type of house or building. The usual faults are: boiler insufficient for requirements; long runs of piping too large or too small for the job; wrong and unsuitable connections; trapped runs of piping; and inadequate cold-water supply arrangements.

It should be realised in the first place that in order to heat the water in a hot-water storage vessel, either tank or cylinder, a circulation of heated water from the boiler is necessary. This circulation is dependent on convection

currents set up in the water when heat is applied to it by the conduction of heat from the fire through the boiler plates. Conduction is the passage of heat along or through a substance—in this case the boiler walls or plates.

If hot water is put into a bottle, the heat from the water will be conducted through the sides of the bottle, and the same principle may be applied to a boiler. This being so, it will be seen how important it is to bring the source of heat into contact with the boiler, so that the heat will be conducted through the boiler to the contained water.

Convection

In order to produce or encourage the action of convection (which consists of allowing the heated or lighter particles of water to rise and the colder or heavier particles of water to take their place, thereby setting up a circulation), it is necessary to arrange the piping and storage vessel so that this action will take place in the most efficient manner.

The connecting pipes between boiler and storage vessel are termed the flow and return pipes, and therefore if the heated water is to rise up from the boiler through the flow pipe, and the cooler water to drop down the return pipe to the boiler, the connections of these two pipes must be at the top and bottom respectively of these two appliances (Fig. 11). In this way a circulation is set up.

These are two of the essential principles of domestic hot-water supply, and should be looked for when reporting and advising on existing systems.

The size of a domestic hot-water system naturally depends on the requirements of hot water at the various points served. If the appliances installed require a total of 40 gallons of hot water at a peak period, then this should be the *minimum* capacity of the storage vessel. If a reserve is needed, this must be added according to additional requirements.

The sizes of the piping must be compatible with the amount of water that is to flow through them during this period. Many systems fail because little or no thought has been given to the sizes of pipes

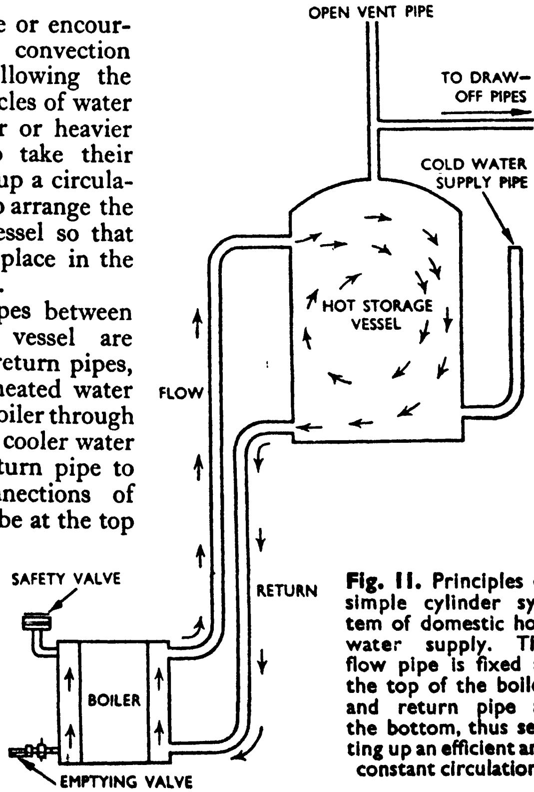


Fig. 11. Principles of simple cylinder system of domestic hot-water supply. The flow pipe is fixed at the top of the boiler and return pipe at the bottom, thus setting up an efficient and constant circulation.

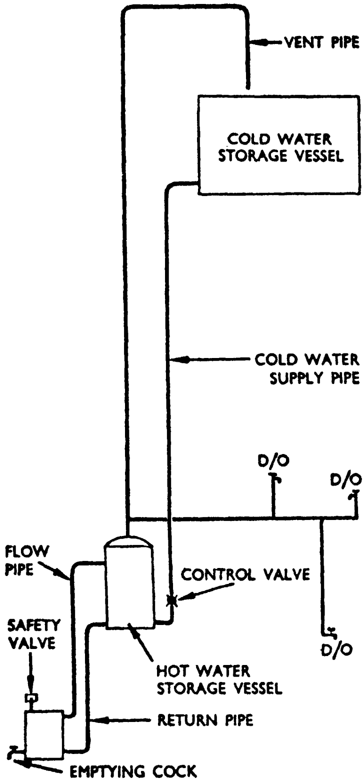


Fig. 12. Simple cylinder system of hot-water supply in which the cylinder is employed as the hot storage vessel.

which are needed to carry the required amount of water in circulation.

In cylinder systems (Figs. 12 and 13) a cylinder-type storage vessel is used for hot-water storage. The draw-offs (D/o's) on a cylinder system are taken from the top of the storage vessel, so that should the cold-water supply to the system be shut off or fail for any reason, the cylinder and boiler will remain full of water. The advantages of the system are that the hottest water is drawn off first from the top of the storage vessel, and that the system cannot be inadvertently emptied; thus preventing possible damage to the boiler owing to lack of water.

The same general principles of connection and draw-off are used quite effectually in modern arrangements of the hot-water storage tank.

The principal components of a domestic hot-water system are: boiler; flow and return pipes; hot-water storage vessel; cold-water supply pipe; open vent or exhaust pipe; draw-offs. Depending on the size of system, there may be a second hot storage

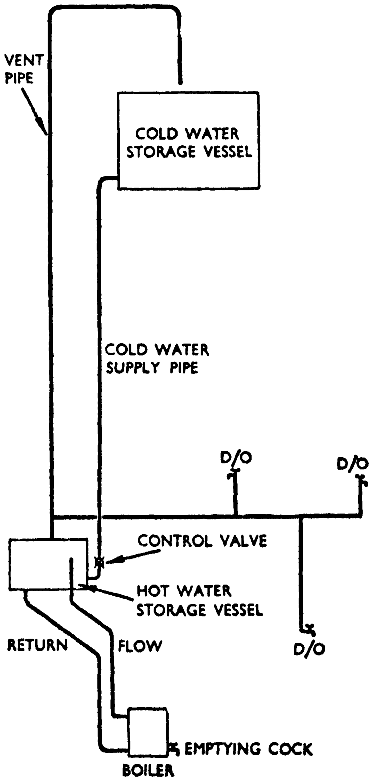


Fig. 13. Cylinder system using rectangular tank as hot storage vessel.

vessel (Fig. 14) which will demand secondary flow and return pipes.

The boiler may be of the fireback type (Fig. 15) inserted as an integral part of a kitchen range or open fireplace; or it may be of the independent type. The difference in the two types is obvious. In the first instances the boiler receives only part of the heat from the products of combustion, the remainder being used for cooking, or heating a room. With the independent boiler (Fig. 16) the fire is situated actually inside the boiler, and lies against the boiler sides, so that with good regulation all the heat from the products of combustion is used.

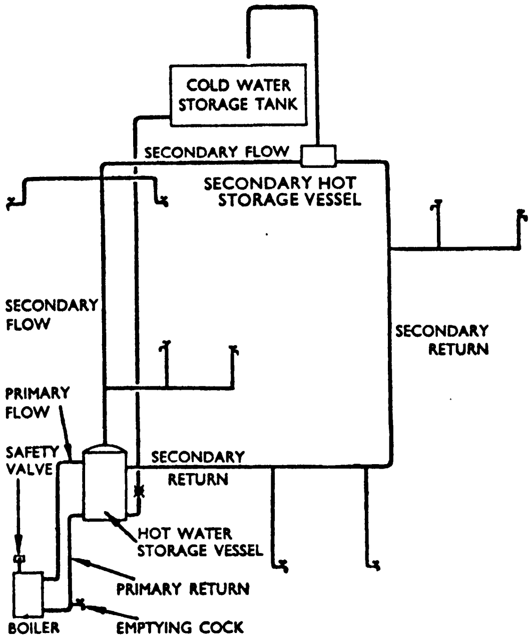


Fig. 14. System in which a second hot storage vessel is used, necessitating secondary flow and return pipes.

Calculation of Sizes

The size of the boiler required should be properly calculated by ascertaining the amount of heat required to raise the temperature of the contained water in the system to a specified degree in a specified time. Most makers' catalogues specify the capacity or capability of a boiler by giving the number of British Thermal Units the boiler will produce per hour in proper circumstances of stoking and fuel. A British Thermal Unit is the amount of heat required to raise one pound of water one degree F. If therefore in a simple domestic hot-water system a 30-gallon storage vessel is to be installed, the minimum size of the boiler can be calculated in the following manner:

Find the number of B.Th.U.'s required to raise 30 gallons of water from 50 deg. to 120 deg. F. per hour.
30 gallons of water weigh 300 lbs.
Degrees to be raised = 120 − 50 = 70 deg.
300 lbs. of water to be raised 70 deg.
300 × 70 = 21,000.
Therefore 21,000 B.Th.U.'s are required.

An allowance must be made for the remaining water in the system and for loss due to inefficient stoking.

Domestic hot-water boilers should be cleaned out periodically, particularly if no water softener has been fitted. Hardness in the

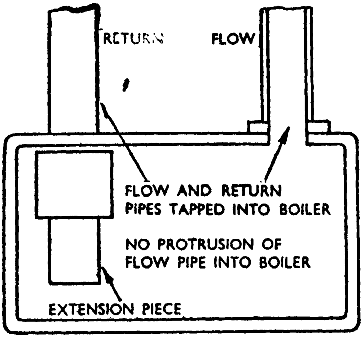


Fig. 15. Fireback type of boiler which forms an integral part of an open fireplace or kitchen range.

form of chalk and lime salts from the water, or "fur", will be deposited in the boiler and will reduce the efficiency and eventually cause damage to the boiler if not removed.

When the hard water, which contains carbonate of lime, is heated, the gases are released, and the chalk is precipitated in the form of scale or crystals. This form of hardness is called "temporary" hardness, owing to the possibility of its removal by boiling.

Permanent hardness consists of sulphate of lime in solution contained in the water, which is not removable by boiling, but which may be deposited in the form of scale through continued evaporation. The effect of this scale on boilers is to produce overheating of the boiler plates through the heat not being absorbed directly into the water. Fracture may also take place owing to the unequal expansion and contraction.

The extent of incrustation, or amount of furring, likely to take place in the boiler or circulating pipes is, therefore, dependent on the hardness, or amount of chalk and lime salts, contained in the water. The salts, or crystals, are precipitated in the boiler and pipes, reducing the waterways and bore, with the possibility, if the incrustation is not removed, of serious damage to the boiler by fracture or distortion.

To clean out a boiler the contained water in the system must be emptied. For this purpose a draining cock or tap is necessary, and the best place for this to be fixed is on the boiler. It is a mistake to install a system without this accessory or even to resort to fixing a plug in the return pipe or boiler. After the system has been emptied it is necessary to remove the manlids, their position being marked in order that they may be correctly refixed.

All the fur should be removed, the boiler sides scraped, and an examination made of the ends of the flow and return pipes, to ascertain whether or not furring has taken place in them. New boiler rings will be required when refixing the manlids, and when tightening up the manlid bolts

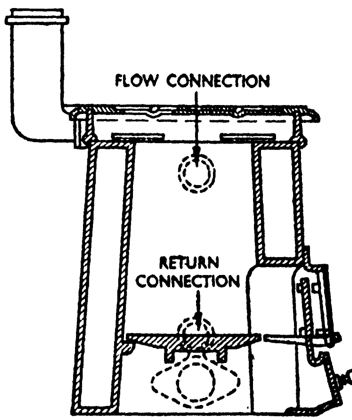


Fig. 16. Typical design of independent boiler. The fire is situated inside the boiler and burns coke or anthracite.

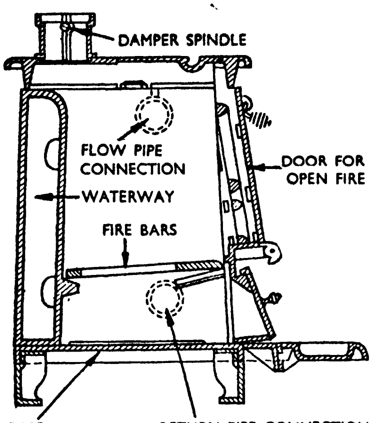


Fig. 17. Typical example of half circular independent type of boiler.

excessive pressure must be avoided, or the bridge at the back of the manlid will be damaged or even broken. In refilling the system all the draw-off taps must be open and the open vent pipe kept free. Without these precautions an airlock is possible. Should an airlock be caused, the best procedure is to empty the system and start again.

Boilers (Figs. 16, 17 and 18) are constructed of wrought iron, steel, copper or cast iron. Repairs to boilers are seldom necessary, but if a boiler should become cracked or broken, and the damage is not too serious, it can usually be repaired by welding. Boiler accessories such as firebars and front and top plates, when burnt or broken can usually be replaced by the makers if the number and year of the boiler are specified when submitting the order.

As already mentioned, the storage vessel may be cylindrical or rectangular. Its position is decided by the layout of the system, and in this connection it should be remembered that the shorter the flow and return pipes the quicker will be the supply of hot water. On the other hand, the placing of the hot storage vessel in an airing cupboard on an upper floor serves a useful purpose and obviates the use of a coil, with its attendant secondary circulation, involving extra size of boiler and heavier fuel consumption.

For the convenience of its connections, the cylinder has the advantage of prefixed tapped flanges, whereas connections have to be made to the rectangular tank by double back nuts after the tank has been drilled. In fixing both types of storage vessel the inside of the vessel must be methodically and carefully cleaned out before the manlid is fixed. This care is necessary in order that iron filings or pieces of metal are not left inside the vessel, as these are almost certain to set up electrolytic action or rusting within a very short space of time.

As a temporary repair to holes

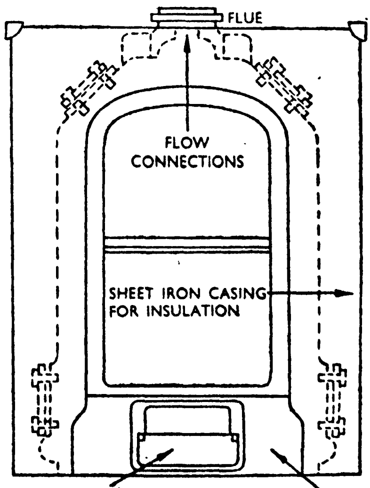


Fig. 18. Sectional type boiler as used for domestic hot-water supply.

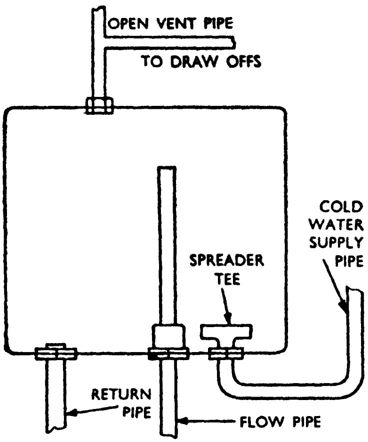


Fig. 19. Tee connected to cold-water supply pipe thus enabling cold water to be spread over bottom of tank.

thus formed, various types of tank mender are on the market. Alternatively a bolt and nut with intermediate plates or washers may be used. As a jointing material red and white lead with chopped hemp may be used, but it is necessary to paint the inner and outer surfaces of the tank.

Types of Storage Vessels

Storage vessels may be obtained in galvanised sheet iron and copper. Owing to the risk of electrolytic action, galvanised iron vessels should not be used with copper piping, and copper vessels should not be used with iron piping. The system should be all copper or all iron. The selection of either will depend on financial considerations, and on the nature of the water in the district. Copper pipe has a smooth bore, and is therefore less liable to furring, and it will better resist the action of soft water.

The cold-water feed pipe from the cold-water storage cistern must be individual to the hot-water system, and no other supplies may be taken from it. The pipe should be connected to the side of the hot storage vessel at a point in the side of the vessel some 3 or 4 in. from the bottom. This applies also to the connection of the pipe to the cold-water storage cistern. There is no need to form a dip in this pipe, as a dip forms a receptacle for rust and other debris that may find its way down the pipe.

If for any reason the cold-water feed pipe has to be connected to the bottom of the hot storage vessel, a tee (Fig. 19) should be connected to it inside the tank to act as a spreader, so that the cold water is spread over the bottom of the tank. This checks the tendency to push up through the hot water to the top of the tank. The size of the cold-water supply pipe is most important. It should be large enough to provide an ample outflow at all draw-offs at a peak period, and its capacity of discharge must therefore equal the number of draw-offs required to be served.

Lead is the usual material for the construction of the cold-water feed pipe, and the cold-water supply through it must be controlled by a stop valve. This valve should be of the fullway type and connected to the pipe at a position near the connection of the pipe with the hot-water storage vessel. In no circumstances should a hot-water system be provided without a stop valve. Its use for controlling the water supply for repairs to the system, or in emergency, is obvious.

It will be realised that without some means of air release, water would not flow into a hot-water

system, and therefore it could not be filled. For this purpose an open vent pipe, sometimes termed an exhaust pipe, is provided. It is taken off the system at the most convenient point for air release and is terminated, preferably, over the cold-water storage cistern.

The practice of terminating vent pipes in the open is deprecated on account of their inaccessibility for maintenance, and consequent rusting; and also on account of the liability of freezing of any water that may be contained therein. The position of its termination over the cold-water cistern should be high enough to prevent an outflow of water from it in normal circumstances. The pipe should be amply protected against frost and corrosion.

A secondary circulation (Fig. 20) is necessary on a domestic hot-water system to enable hot water to circulate from the storage

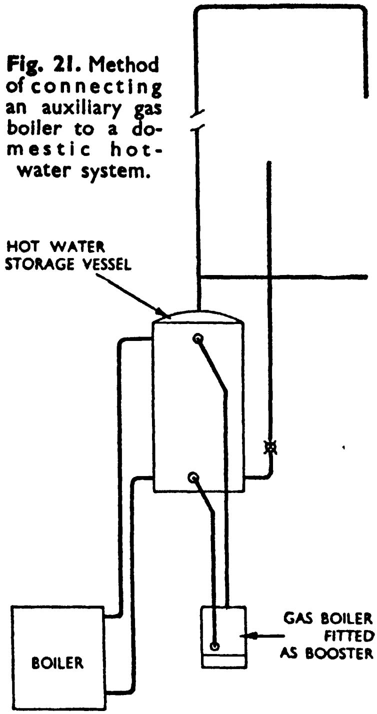


Fig. 21. Method of connecting an auxiliary gas boiler to a domestic hot-water system.

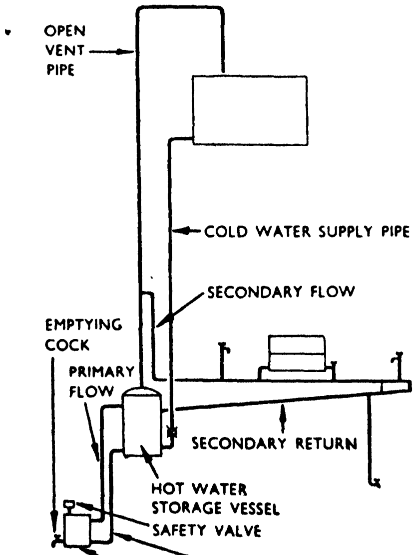


Fig. 20. Secondary circulation for towel rail on a domestic hot-water system.

vessel. This secondary circulation is necessary for the provision of a towel rail, or coil for a linen cupboard, or the supply of water to an isolated fitment. In the last-mentioned instance the secondary circulation is provided to prevent a waste of water, by drawing off and running to waste the cold water lying in a long length of single pipe, before hot water is available.

Boosting

The term boosting in connection with a domestic hot-water apparatus is meant to imply that the existing solid fuel boiler is implemented by a secondary means in the shape of an additional boiler usually employing another type of fuel, usually either gas or

electricity. The reasons for this provision are the need for a quicker and increased supply during peak periods, or the incapacity of the existing boiler.

The use of gas demands the provision of a gas boiler or circulator, preferably connected directly, by means of a separate flow and return pipe, to the existing hot-water storage cylinder or tank (Fig. 21). The gas boiler should not be connected to the existing flow and return pipe from the solid fuel boiler, owing to the risk of inter-circulation between the two boilers. In this connection the use of valves on either installation must be prohibited, as they may become a potential source of danger in inexperienced hands.

The hot storage vessel should be lagged, and preferably the circulating pipes as well, to prevent loss of heat and the consequent increased use of gas. The flue pipe from the boiler or circulator should be fitted with a baffler, and be terminated in the open air in a suitable position where draughts will not dispose of the effects of combustion through windows and doors.

An additional advantage of a supplementary boiler or circulator is that it can be used in the summer months, when it may not be desired to run the solid fuel boiler.

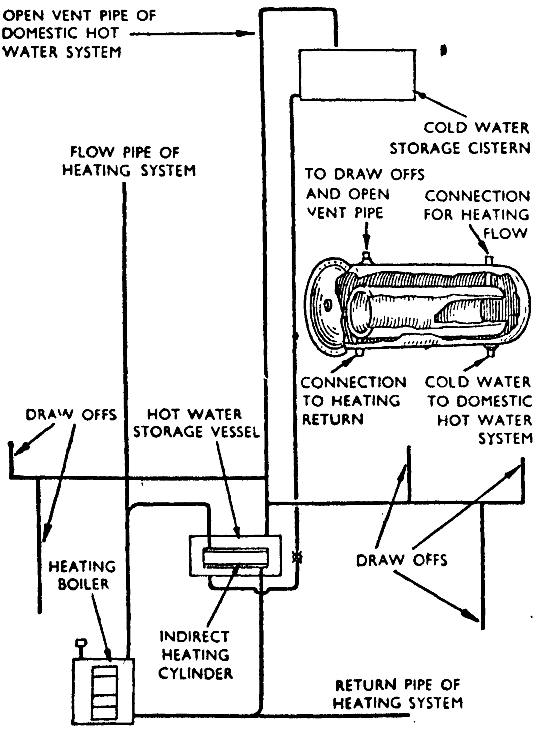


Fig. 22. Indirect system of domestic hot-water supply. The water is heated indirectly by heated water or steam.

The boiler or circulator is fitted with an automatic thermostatic control, so that when the water reaches a certain temperature the gas will gradually be reduced and shut off, leaving only a pilot light for lighting the burners when cooler water causes the thermostat to open the gas control.

A similar method of thermostatic control is employed in the case of heating the hot storage vessel by electricity. By this system the water is heated by means of immersion heaters which are installed within the storage vessel. The immersion heaters are connected up to an electric power switch.

An indirect system of domestic hot-water supply (Fig. 22) is one in which the water used for domestic purposes is heated indirectly by heated water, or by steam being passed through a coil or cylinder placed in the hot storage vessel. In this way the domestic hot water does not pass through the boiler. The advantages of the system are that only one boiler is necessary for both systems, and that after the initial deposit has taken place in the boiler (the same water being used plus a small quantity for evaporation) only very slight further deposit occurs.

The disadvantages of lighting the boiler during the summer months may be obviated by the use of a secondary circulator for use during this period and as a booster at other times.

It may be difficult to recognise the various connections of the system, and care should be taken before repairs are contemplated or commenced. Otherwise wrong connections may be made with the subsequent failure of the system.

The domestic system cannot be emptied through the boiler; only the heating system can be emptied in this way. Repairs to this side of the system can be made in the usual way by using the controlling valve on the cold-water supply pipe. The system can then be emptied as far as the top of the cylinder. It is a good plan to fix a draw-off cock on to the cold-water supply pipe between the stop valve and the connection to the cylinder. In this way the cylinder can be emptied.

If the heating system is to be emptied for repair or addition, it will be necessary to tie up the ball valve, or otherwise control the water in the feed tank to this system. The system can then be completely emptied by opening the draw-off cock at the boiler.

GLAZING

THE first item to be considered in connection with glazing is the tools required for the work. Two of the most important items of the glazier's kit are the rule and pocket-book. The rule may be of the 2-ft. or 3-ft. folding type that fits into the pocket. It must be of good quality, otherwise after a very short while the figures will be worn off and mistakes made. The pocket-book is essential to the repairing glazier, to note the sizes of glass required and other materials, and to provide a future reference for checking materials used on a particular job.

Probably the most essential item is the glass cutter (Fig. 1). If a diamond-cutter is not available a good wheel-cutter of the six-wheel type, or Monce, should be obtained. Good work can be done with this type of cutter if it is looked after and properly used. Any thickness of glass from 15 ozs. to ¼ plate can be cut with the wheel-cutter.

The following hints will be found to be useful in connection with the use of the wheel-cutter. Carry a small bottle of turpentine or paraffin from job to job. Before making a cut on the glass, dip the cutter into the turpentine and proceed to draw the cutter along the straight edge across the glass. The wheel spindle will be

lubricated and the cut made quite smoothly. Never attempt the same cut twice.

Other tools, most of which are illustrated in Fig. 1, include $\frac{1}{2}$-lb. Warrington or tack hammer; pair of pincers; dusting brush; $\frac{1}{4}$, $\frac{3}{4}$ and 1 in. wood chisels; pair of broad-nosed pliers; rapid sharpening oilstone and hacking knife.

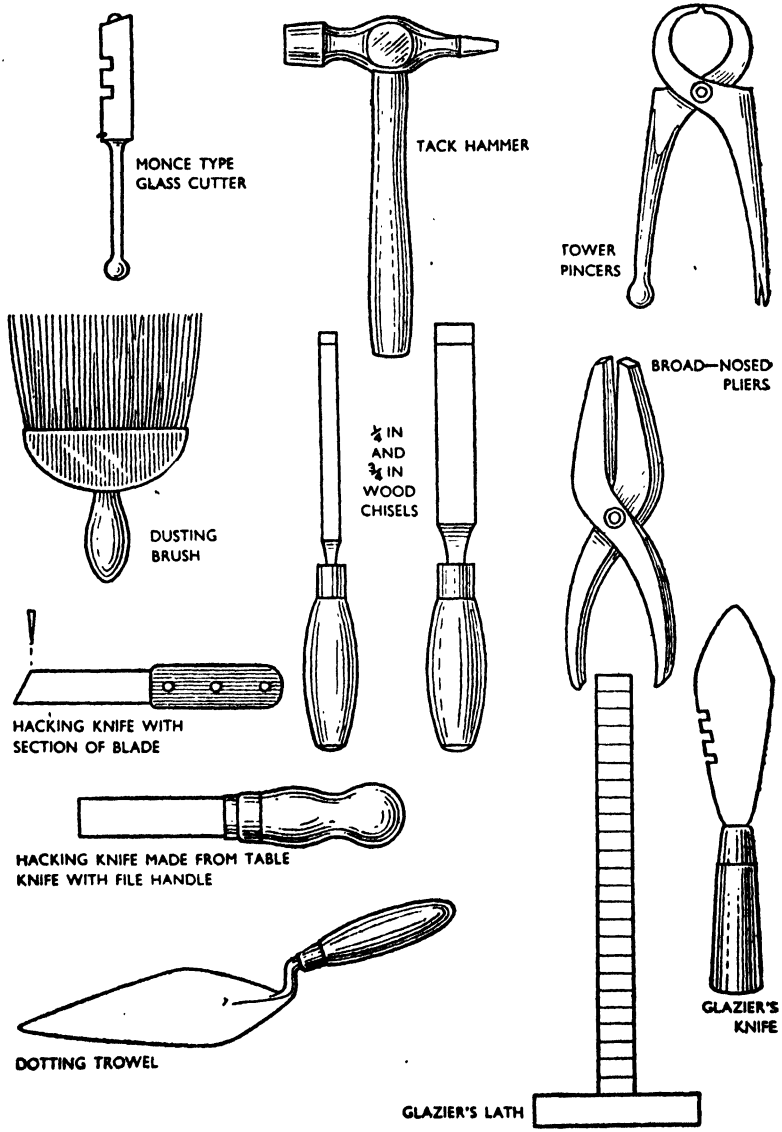


Fig. 1. Selection of useful tools which form the principal part of the glazier's kit.

In the opinion of many glaziers the ordinary hacking knife is not a suitable tool for the work it has to do. The following reasons are given: the blade is too heavy; the pointed end soon wears out with sharpening; the wedge-shaped section of the blade takes away control of the tool from the user's hands. The writer prefers a substantial table knife cut off to about 3 in. long, firmly fitted in a file handle for ease of handling. This tool (Fig. 1), if kept in good order, can be used as a hacking knife and as a chisel knife.

In selecting a glazing knife it should be remembered that there is a difference between a glazing and a stopping knife. The difference is in the stiffness of the blade of the former against the flexibility of the blade of the latter. A tool with a stiff blade is to be preferred for glazing, and for this reason some glaziers use a chisel knife. A small dotting trowel (Fig. 1) which has been shaped up on a grindstone is most useful. It does its work well, especially in awkward corners, because of its cranked handle.

The glazier's square and lath (Fig. 1) may occasionally be required in jobbing or repair work. A certain amount of ingenuity and improvisation may be required in this direction.

To carry glass a piece of equipment known as a "frail" (Fig. 2) is required, to avoid danger of breaking.

In the work of the glazier it is a good maxim to measure twice and cut once. This will save unnecessary journeys, time, temper, labour and, what is equally important, the cost of the job. Use a rule on which the figures are clearly legible. Mistakes are easily

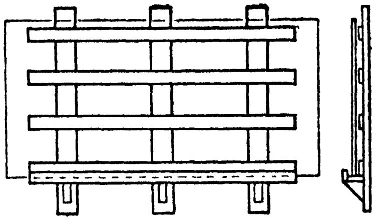


Fig. 2. An invaluable piece of equipment which is used for protecting sheets of glass from damage during transit.

made; for instance, it is quite possible to read 6 upside down for 9. Always prick off the size with the chisel or hacking knife when the size is longer than the rule end.

For the purpose of explaining the procedure to be adopted in glazing, an actual job will be described. For this purpose it will be assumed that all the glass of an occupied house is to be reinstated. Cleanliness is most essential, as nothing is more annoying than to find putty trodden about a house. Dust sheets and a broom must be used.

Working to Plan

Operations should be started at the top of the house and a system adopted. While the hacking out is being proceeded with, measurements can be taken, any glazing or sash bars that are damaged can be repaired, and a certain amount of glass can be ordered. If two men are on the job, one can be hacking out while the other is glazing and cleaning up.

When taking measurements it is advisable to allow $\frac{1}{8}$ in. clear under inside sash measurements. If this is done the glass will bed down properly, but, on the other hand, if too tightly fitted it will probably break on the slightest jar. If the

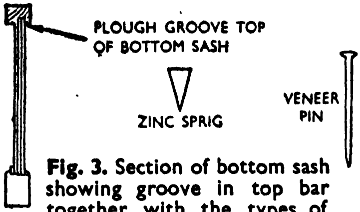


Fig. 3. Section of bottom sash showing groove in top bar together with the types of sprig used in glazing.

sash is out of square, measure the glass over size, say in the length; and, before bedding, lay in the glass, and cut ⅛ in. under to sight line by means of a straight edge.

It is advisable to carry out all the work of hacking out and glazing from the inside of the house; and, as sashes—with few exceptions—are sliding ones, it is as well to take them out of the frames. The work will thus be facilitated, and at the same time an opportunity will be given to renew any broken or defective sash cords.

After the sashes have been taken out, the work of hacking out and glazing can be proceeded with. It is necessary to lay the sash perfectly flat on a table or bench. An improvised bench can be made up by laying scaffold boards on two carpenter's stools. The hacking out should be done by using the hammer and hacking knife, and if necessary the ¼-in. chisel.

Removing Old Putty

First remove the sprigs that held in the old glass. All the sprigs must be removed, as failure to do this is disastrous to the edge of the knife or chisel. The old putty, if soft, will be easy to remove, but, if old and hard, patience will have to be exercised. One method of expediting the removal of old putty is to make a number of cuts at right-angles to the frame. In the top bar of the bottom sliding sash will be found a groove, which often proves the most difficult portion of the sash from which to remove the putty. To do this use the ¼-in. chisel, starting very carefully at one end, cutting as it were a small trench about 1 in. long, so that the chisel can be edged under any pieces of glass that may have broken off in the putty. By using this method it is quite possible to lever out fairly long pieces of glass and putty at the same time. The putty having been removed from the rebates and groove, it is advisable to run the shavehook along to remove any small pieces of putty, and to leave the woodwork ready for the next operation —namely, that of coating the bare timber with shellac knotting.

Purpose of Coating

This is done to prevent the oil in the putty being absorbed into the bare wood, which would not only make the bedding stiff when receiving the glass, but would also be detrimental to the putty, which would deteriorate in quality. When sashes are newly made and primed for glazing, this coating is not necessary. If time will allow, the woodwork can of course be primed instead of coated.

The bedding putty may now be placed in the rebates and groove (Fig. 3). The putty should be moderately soft, and be "run in" by holding the putty in the hand, and, by an action which can be quickly learnt, fed into the rebate with the ball of the thumb. By continued practice the glazier will putty sashes at an amazing speed. The piece of glass about to be bedded-in should be checked for size by *offering in* before puttying.

In putting the glass in the sash,

place the top edge into the plough groove first, and gently press in the glass around the outside edges by rubbing the thumb firmly towards the outside edges. The bedding putty spreads out, and, when the glass is firmly bedded, the sprigs are inserted. Sprigs may be either small triangular pieces of zinc, veneer pins or small panel pins (Fig. 3). These are fitted by laying the sprig flat on the glass and driving in with the hammer, or by using the side of the blade of the ¾-in. chisel laying it flat on the glass.

Application of Putty

The next step is the application of the front putty, and for best working the putty should be slightly stiffer than that used for bedding. The putty is applied by means of the dotting trowel or any tool that is preferred for the purpose. One side of the tool should rest on the woodwork and the other on the glass, and the putty should be run round the sash with the tool, using a firm pressure. The tool should be kept clean and bright, and when in use should

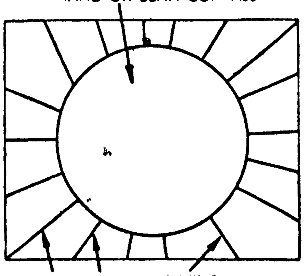


Fig. 4. Simple method of cutting glass to shape while on the job. When lightly tapped from the underside the surrounding glass falls away, leaving only the clean circle. By this method glass can be cut to almost any shape.

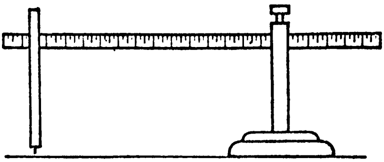


Fig. 5. Method of cutting a circle in glass by means of a beam compass.

be dipped in water to reduce the drag of the putty and to impart a smooth finish. Afterwards the putty is brushed lightly with the dusting brush to remove any slight nibs left on, and to impart a clean finished look to the job.

The next operation is to cut off the back putty; dust off with brush and paint if required.

For glass hung in shapes other than squares, such as circular or partly curved work, correct shape and measurement are essential. If the glass is to be cut and supplied to shape by a merchant, then the glazier will have to supply him with an accurate templet. This can be done either by using stout brown paper or cardboard cut to fit.

If on the other hand, the glass can be cut to shape on the job, the best way to do this is to lay the glass on the frame, and to cut freehand with the wheel-cutter to ⅛ in. inside the sight line of the curve, keeping the cutter vertical and maintaining a firm pressure. By making cuts at right-angles to the curve and lightly tapping from the underneath side of the glass, the curve will be cleanly left to shape (Fig. 4). After a little practice ovals, and even circles, can be cut to fit any sash that has to be renewed. Fig. 5 illustrates the method of cutting a circle in glass with the aid of a beam compass.

The re-glazing of iron or metal

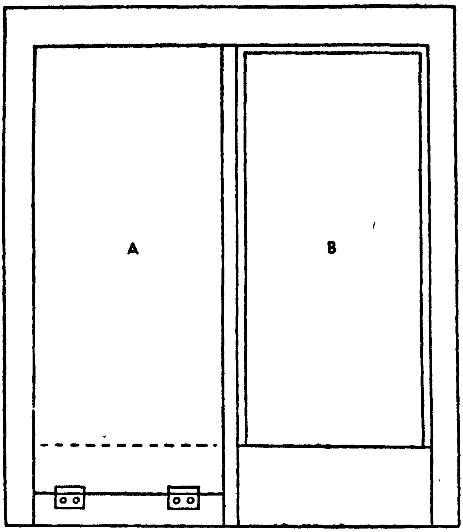


Fig. 6. Roof light. A. Glass in position showing copper clips; B. sash ready to receive glass.

frames or sashes will present little trouble. The old putties can be easily removed without any fear of damaging.

The only difficulty may lie in a lack of fixing. On most metal sashes, however, means are provided in the form of small holes through the bar in which are inserted pieces of lead or copper wire, or special spring clips to hold the glass. On others the use of hard-setting putty has to fill this purpose.

A putty made up of linseed oil, whiting and red and white lead will set hard and firm, and is recommended for glazing metal sashes. Linseed-oil putty without the admixture of a hardener as described should not be used on metal sashes.

Linseed-oil putty is admirably suited for the work of glazing. A mixture of fish oil and whiting should not be used, as has been done in many cases in the past. The result of this use is that the putty will not harden, and for years afterwards the putty will be found to be as soft as when it was put in. Paint will take months to dry on it, relying mostly on the dust that accumulates on it to dry it off. It will be seen, therefore, that the glazier will do well to ensure that his putty is genuine linseed-oil putty, a simple mixture of whiting and linseed oil.

Repairs have often to be carried out involving the use of Hartley's rolled and wired glass. This is particularly the case in reglazing roof or lantern lights (Fig. 6). The usual procedure for hacking out, cleaning and priming or knotting is followed. Clips of copper fixed with brass screws to the bottom of the woodwork are used to clip round the bottom edge of the sheet (Fig. 7). Bedding

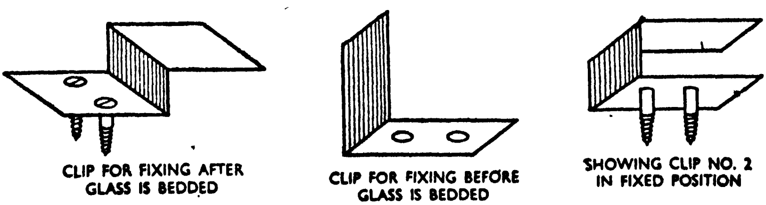


Fig. 7. Types of clip used for clipping round the bottom edge of glass.

Fig. 8. Section through roof light with front putties replaced by painting.

and pressing-in are performed as in sashes. Front puttying may be used, but it may be preferable to clean off the putty flat with the glass and paint with a fat oil paint well spread (Fig. 8).

A leaded light is made up of lead H-section strips termed "cames", cut, fitted and soldered, into the shapes required, and into which the glass is fitted and bedded. The cames are of different sections, selected according to the thickness and type of glass. At one time, when the manufacture of leaded lights was considered to be solely plumbers' work, many plumbers' shops had their own came-drawing machine. To-day, however, the manufacture of leaded lights has passed mainly into the hands of certain specialist firms.

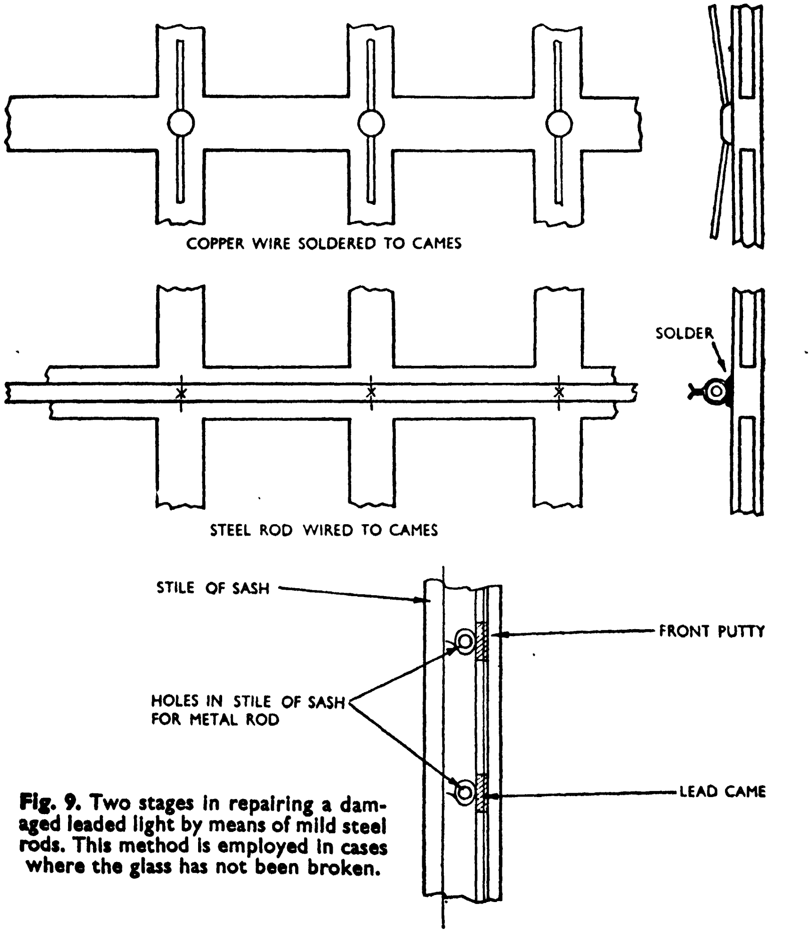


Fig. 9. Two stages in repairing a damaged leaded light by means of mild steel rods. This method is employed in cases where the glass has not been broken.

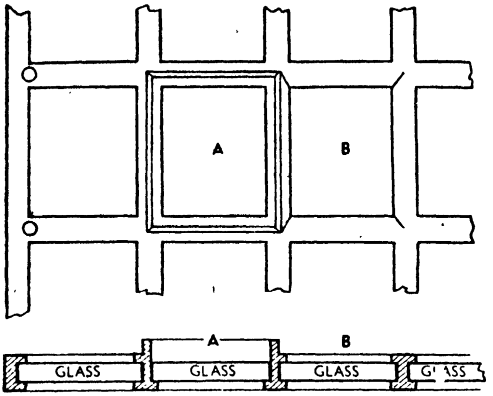


Fig. 10. (*Top*) Portion of leaded light showing method of renewing glass by slitting cames as in pane *B* and lifting as in pane *A*; (*Bottom*) section through cames showing lead lifted to receive glass. *B* shows the lead after it has been pressed back into position.

As a result of enemy action, blast and suction have played havoc with leaded lights, particularly where strengthening bars have not been fixed. It may be as well to mention that at one time the plumber always took the precaution of providing and fixing iron strengthening rods as shown in Fig. 9. This made a strong job of fixing, but unfortunately, in these days of mass-production, it is frequently found that this simple precaution has been completely omitted.

The best way to deal with a damaged leaded light, where the glass has not been broken, is first to remove the light from the frame and carefully lay it on a flat surface. Flatten and straighten the light, and solder some pieces of copper wire on to the lead in suitable positions to receive small-diameter iron or mild steel rods as illustrated in Fig. 9. The rods are fitted into holes countersunk in the wooden frame, the light is refitted and puttied, and secured to the rods by means of the copper-wire ties.

Where the glass has been broken and has to be removed from the lead prior to the fitting and fixing of new glass, take a sharp knife, cut the four corners of the lead around the square, and then place a thin flat tool under the edge of the lead and work it up until it is upright (Fig. 10). Remove the broken glass and cut out the old paint or cement, whichever was employed in bedding in the previous glass. It should be possible to cut the new squares out of salvaged glass.

When the new pieces of glass have been placed into the cames, the upright lead is pressed and rubbed flat on to the glass with a piece of hardwood cut and nosed especially for the job, until the lead is quite flat on the glass. The four corners that have been slit remain to be dealt with. Clean the lead around the slit and, using a little resin and tallow as a flux, drop a small dot of solder (blow-pipe solder is the best) on to the joint and solder with the copper bit, using the bit in a vertical position and making a neat repair. The low melting point of the blow-pipe solder will prevent the lead from being melted. The whole of the sash is then painted with a lead smudge paint, to which has been added a quantity of gold size. Rub well in between came and glass with a sash tool. The surplus paint can be then rubbed off with a rag and the sash refixed.

CHAPTER 7

FLUES AND FIRES

PRINCIPLE OF FIREPLACE DESIGN. EXTERNAL CONDITIONS. RAISING A CHIMNEY. DAMP AND LEAKING FLUES. FLUE OBSTRUCTIONS. CHIMNEY-POTS. FLAUNCHING. ANTI-DOWN-DRAUGHT POTS AND COWLS. OLD FIRE-PLACES. FIREPROOFING. BY-LAW REQUIREMENTS. GRATES AND RANGES. PORTABLE BOILERS. DEFECTS IN FIRES AND STOVES. HEATING COSTS.

THE normal action of a fireplace and flue depends on a continuous current of air passing up the flue and carrying with it the smoke and gases of combustion. It is therefore necessary to have a reasonable supply of air entering the room and passing through the fireplace into the flue, and an unobstructed exit for the smoke-laden air as it leaves the chimney. If either the air supply or the chimney exit is obstructed, a check on the up-current will occur and actual down-draught may result.

Fireplace Design

Count Rumford's Principles.—These principles were laid down by Count Rumford in the eighteenth century, and they are still generally applied by the Building Research Station. There are four essential principles regarding fireplace design (for open coal-burning grates) as follows:

(1) Correct design of the throat, which should be 4 in. wide and 6 to 8 in. deep, and should be perpendicular over the fire. Smooth internal surfaces should be provided to all smoke passages and, in particular, the entrance to the throat under the front arch or lintel should be rounded.

(2) A smoke shelf should be provided. This should be horizontal, and level with the top of the throat, which should be 6 to 8 in. above the top of the fireplace opening.

(3) The fireplace should have splayed sides in plan. Count Rumford's suggestion was that the width at the back of the fireplace should be about one-third of that of the opening.

(4) There should be sufficient depth from the face of the chimney breast to the back of the fireplace to prevent smoking, caused, for example, by draughts across the fireplace opening.

The fireplace and flue entry illustrated in section in Fig. 1 A have been designed on these principles. Fig. 1 B shows a section commonly adopted in modern work, which is usually successful.

In repair work to existing domestic fireplaces it is desirable to form the fireplaces to the shape and dimensions shown.

Flues.—There is still some difference of opinion regarding the effect of bends in flues. Great changes of direction are certainly not desirable, apart from the difficulties such changes cause to flue sweeping. It is often contended that a slight bend from the fireplace throat to the main run of the flue at the side of the chimney-

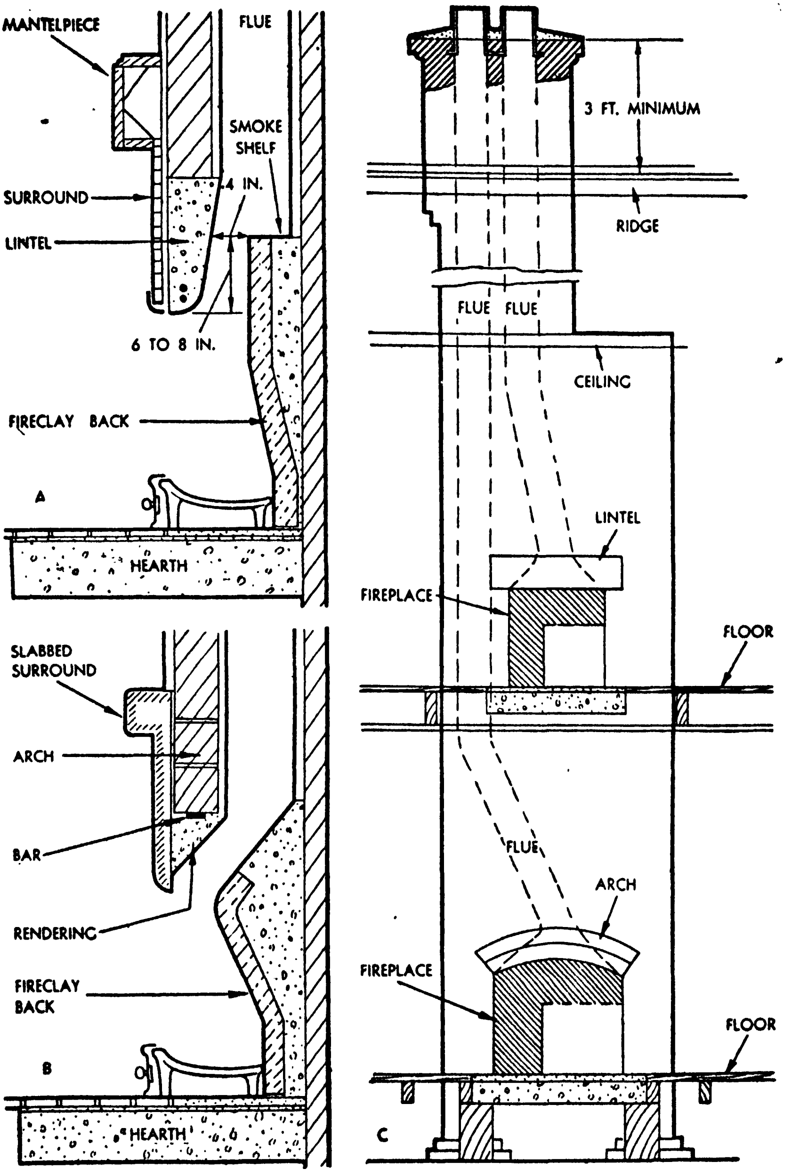


Fig. 1. *A.* Section through fireplace designed on the principles of Count Rumford; *B.* section commonly adopted in modern work and which is usually successful; *C.* elevation of chimney breast showing flues and bends. Provided that the change of angle is only slight the position of the bend is of no consequence, but the bends shown in this illustration are typical of good practice.

breast accelerates the movement of smoke and gases, but the Building Research Station prefers a slight bend near the top of the flue. Practical conditions generally decide the positions of slight bends. Provided that the change of angle is slight, the position appears to be immaterial. The bends which are shown in Fig. 1 C are typical of good practice.

External Conditions.—As the wind strikes buildings, trees and other objects, areas of air pressure and suction are set up. The area of pressure is on the weather side (the side on which the wind strikes), and the area of suction on the opposite side. These areas extend above the roof, whether the roof is flat or pitched. A chimney outlet in an area of pressure is badly placed, as in high winds the pressure may be greater than the upward pressure of the smoke and gas-laden air rising up the flue, and therefore down-draught will result.

Suction may be beneficial; but as the wind changes direction, so do the areas of pressure and suction. The main practical lesson we learn from this is that the chimney outlet should be high enough to avoid interference from pressure and suction.

Position of Outlet

As a general rule the chimney outlet should be 3 ft. above the highest point of intersection of chimney stack and roof slope, as in Fig. 2 A. Down-draught can often be cured merely by raising a low chimney above ridge level, as in Fig. 2 B.

Adjacent buildings modify the areas of pressure and suction around the building under consideration. In some cases it is not sufficient to carry the chimney up 3 ft. above ridge level. A bungalow, for example, may have the ridge at a much lower level than that of the adjoining houses.

On steep hills one building may be lower than an adjoining building. In Fig. 2 C the house in the lower position has chimneys which are below the ridge level of the adjoining house, although above its own ridge. The relatively low chimneys will probably suffer down-draught. In Fig. 2 D the two houses, although on level sites, are of different heights. Here again the lower chimneys are at a disadvantage.

Extension of Buildings

Fig. 2 E illustrates what takes place when a new high building is erected against an existing building. If the existing chimneys are left at the old level, there will certainly be trouble with down-draught. In such a case the owner of the new building should build up the chimneys on the existing building to such a height as will ensure proper up-draught.

Trees near a building may cause down-draught by creating areas of pressure and suction. A typical case is illustrated in Fig. 2 F. If it is impracticable to raise the chimney above the area of pressure, the tree should be lopped or felled.

Raising the Chimney.—Where it is clear that the existing chimney outlet is too low (and consequently within an area of pressure), an almost certain remedy is to raise it to bring the outlet above the disturbed area. This can be done either by building up the chimney in the existing materials or (in some cases) by fixing a tall chimney-pot. The first method is the best. A tall chimney-pot may

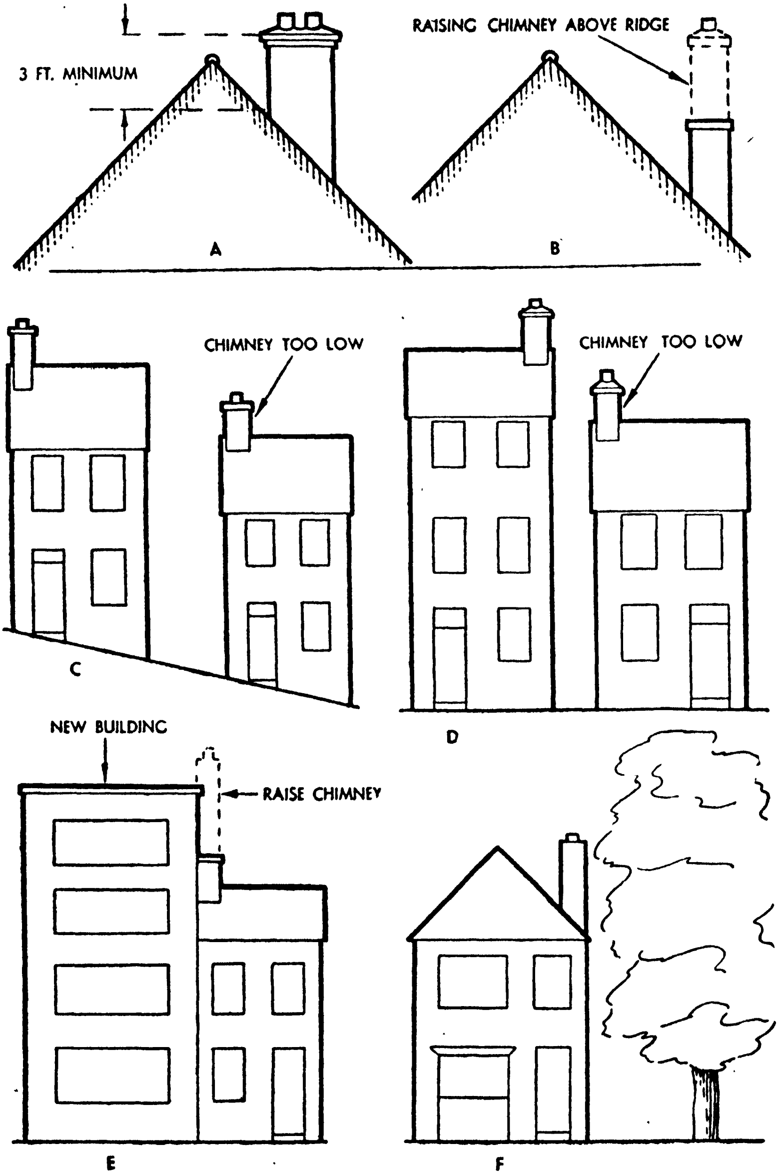


Fig. 2. *A.* Minimum height of chimney above roof. By-laws require that chimneys shall be at least 3 ft. above the highest point of intersection of chimney stack and roof slope; *B.* raising a low chimney; *C, D* and *E.* chimneys which are too low in relation to the higher neighbouring buildings; *F.* tree is in too close proximity to house, thus causing down-draught by creating areas of pressure and suction.

crack and break up in time, and it is quickly saturated with rainwater and becomes a poor heat insulator.

When building up a chimney, first make sure that the existing brick or other material provides a firm base for the new work. Any defective courses must be taken down. In some cases this will mean taking the chimney down to roof level. This is a point to watch in estimating. A chimney is so exposed that the materials and workmanship should be of the best quality if the work is to last. A lime-cement mortar or a cement-mortar of moderate strength should be used.

Damp Flues.—A damp, cold flue tends to retard the velocity of the rising smoke and gases. It is inevitable that a certain amount of rain should pass down the chimney, but this is not markedly harmful in comparison with the damp which penetrates thin brick flues with decayed pointing or brick or stonework. The outer walls of chimney-stacks should be 9 in. thick if high resistance to damp and a high degree of heat insulation are desired. Often they are only 4½ in. thick, and if badly decayed it is obvious that the interior must be very damp, and the decay will soon spread to the interior. A chimney in this condition should be taken down to roof level and rebuilt.

Corbel Courses

It is usually possible to corbel out to make the chimney walls 9 in. thick. The corbel courses in brickwork should step out not more than 2¼ in. each. The inner dividing walls of a chimney-stack (called the *withes*) are usually 4½ in. thick. This is sufficient, provided that the materials are sound and the joints properly filled. The bond used in brickwork is *chimney* or "*shimney*" bond (Fig. 5).

Leaking Flues are not uncommon, and they are often troublesome to trace and cure. If the lining and joints of the flues decay, smoke may leak from one flue to another; or from a flue it may leak out into the space in a timber floor, in the roof, or from the chimney direct to the open air. Leakages through the outer walls of the flue are fairly easy to trace, and can be remedied by making good the defective portion.

Leakages in withes, causing smoke to pass from one flue to another, are often difficult to deal with, unless they are near a fireplace opening. It may be necessary to take out portions of the chimney-breast or backing—a costly and troublesome job.

Rebuilding Flues

In old buildings it is sometimes found that one flue serves two fireplaces. If down-draught is experienced (sometimes the smoke from one fireplace blows out at the other fireplace), and it is clear that the chimney is high enough and in good condition, the only thing to do is to build a new flue, so that each fireplace has its own separate flue. On an external wall the new flue may be built outside. On an internal wall more work is involved; as the new flue must be taken through floors and roof and plastering, making good and decorating are involved. The new work must be bonded to the old at least one course in five.

Flue Linings.—A flue for a solid fuel fire is usually 9 × 9 in. For domestic fires this is sufficient, and a larger flue is usually a disadvantage. The lining is ½ to ¾ in.

thick, reducing the size to about 8 × 8 in.

Flues may be lined with mortar or fireclay flue pipes. The mortar lining, called *pargetting*, may be of lime or cement, but a lime-cement mortar is probably best. The old-fashioned pargetting consists of lime-mortar with the admixture of one-third by volume of cow dung. Pargetting should be at least ½ in. thick, rendered as the flue rises, and finished with a fairly smooth face with rounded angles. On bends it is essential to fill properly and render on the rough offsets of brick courses.

Fireclay flue pipes are better than mortar pargetting. Pargetting tends to crack and fall away from the flue. Fireclay flue linings will stand the heat from an ordinary domestic fire without cracking. They are made in two shapes: square on plan, and circular; about 9 in. square or diameter, and in lengths of about 2 ft. They can be cut to mitre at angles.

Renewal of Linings

Flue linings obviously cannot be renewed without cutting away one wall of the flue—an operation rarely attempted owing to the cost. But if the withes or joints are so decayed that smoke is leaking out, the flue must be relined. It is better to do this at the outset than to attempt cheap but useless patching.

Apart from the fact that flue linings seal the walls of the flue, they assist up-draught by providing a smooth surface, which reduces friction to a minimum and improves the heat insulation of the flues.

Obstructions in a flue are sometimes responsible for down-draught. Pieces of the flue lining may break away from the flue wall and become jammed across a bend. With the flue lining defective the surface of the bricks or stone may break up and cause an obstruction. Chimney-pots often crack, and the pieces may fall into the flue. In flues which are not often used birds may build nests in the chimneys, and debris may thus fall into the flue.

Rodding, using a scraper on the end of the rods, will often clear small, loose obstructions. Where the rods cannot be pushed up from the fireplace they can often be pushed down from the chimney top and the obstruction cleared. If rodding fails to clear the flue, it will at least enable the position of the obstruction to be fixed by measuring the rodding length. The flue should then be opened at the point found by measurement and the obstruction cleared, the hole being then made good.

Chimney-Pots.—According to the Building Research Station there is no advantage in a chimney-pot of the ordinary type. Special types as shown in Fig. 3 A, B, C and D are used for combatting down-draught. In many buildings erected in recent years chimney-pots have been omitted. As they sometimes crack and break up, they may cause trouble instead of preventing it. It may not, however, be wise to remove an old chimney-pot without replacing it with a new one, as the chimney top will thus be lowered, and down-draught may result.

In setting a chimney-pot, it should be built into the brickwork or masonry of the chimney. It is very bad practice to set the base of the pot on the top of the chimney, relying on the cement bedding and flaunching to hold it

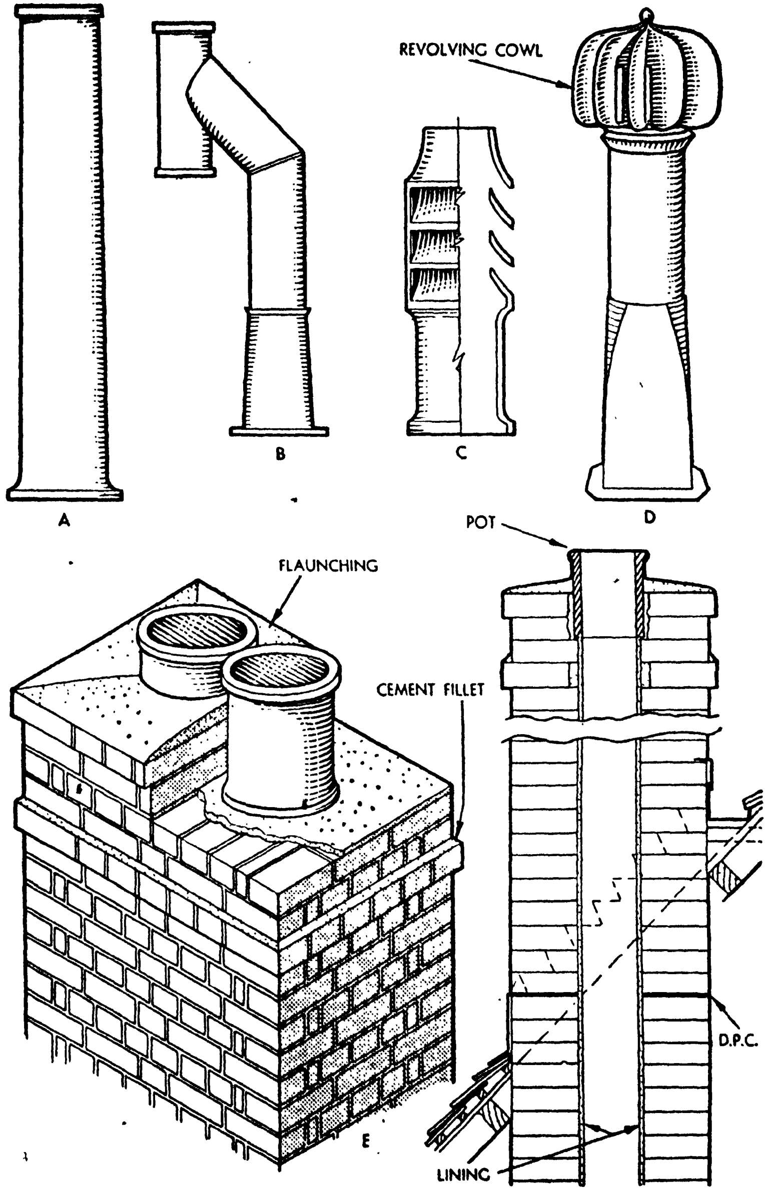


Fig. 3. Special types of chimney pot which are employed to combat down-draught. *A.* Tallboy pot; *B.* elbow tee pot; *C.* louvred pot; *D.* revolving cowl; *E.* chimney top in English bond showing flaunching and pot setting. Flaunching prevents damp penetrating through the chimney walling by allowing rainwater to run off.

against the force of the wind. The base of the pot should be set at least one course of brickwork below the top, as in Fig. 3 E. In old brick chimneys these top courses are often badly decayed, so it is in any case advisable to take them down. If the old bricks are decayed they should be replaced with new ones, selecting sound, well-burnt bricks and using a cement-mortar of moderate strength.

Flaunching a chimney top means covering it with cement-mortar trowelled to a sloping surface so that the rainwater runs off, as in Fig. 3 E. If this is not done, damp will readily penetrate down the chimney walling. A cement-mortar of moderate strength is recommended. The addition of a waterproofing compound will make the flaunching impervious, but a very rich cement-mortar is not recommended, as it tends to develop shrinkage cracks. The brick or stone chimney top must be in good condition before flaunching. The cement-mortar will not remain in good condition on a defective base. If necessary take off the top courses and replace with new material.

Pre-cast Chimney Tops

Pre-cast concrete chimney tops can be used in place of flaunching. These are slabs with round holes for the chimney exits. Chimney-pots are not necessary. The pre-cast tops are made in various standard sizes by firms specialising in pre-cast products, but they can be produced to special sizes.

In flaunching an old chimney it is usually necessary to re-point the chimney generally. Any projecting courses or mouldings should be repaired, working a sloping cement fillet on top. This *weathering* serves a purpose similar to flaunching, by providing a fall for drainage.

In doing this work remember that a chimney is very exposed, and every precaution should be taken to ensure first-class workmanship. Rake out all joints, remove all defective bricks or stones, and wash away all loose material and dust. Wet the work well before applying mortar, and protect it from hot sun rays by covering with sacking. Such work must not be carried out in very cold or frosty weather.

Dampproof Courses

A chimney should have a dampproof course set at roof level and it is better if this d.p.c. is stepped to follow the roof slope. The d.p.c. prevents any damp which may soak into the chimney from penetrating downwards to the chimney-breast or ceiling below. If the lack of such a d.p.c. is a cause of dampness, the chimney should be taken down to roof level and a d.p.c. inserted. Slates in cement may be used for a straight d.p.c., or lead for a stepped d.p.c. Felt and bitumen are obviously unsuitable owing to the heat.

Anti-Down-Draught Pots and Cowls.—There are so many types of pots and cowls designed to cure down-draught that it is impossible to describe them all here. There are four main types:

The Tallboy Pot (Fig. 3 A), made in burnt clay, asbestos-cement and in sheet metal. This is suitable for cases where the down-draught is due to the chimney top being too low, as already described.

Elbow Tee (Fig. 3 B), usually in sheet metal, though also made in

burnt clay. The idea is that down-draught will pass down the tee and not down the chimney. The shape is ugly, and the fitting is not always effective.

Louvres (Fig. 3 C), made in burnt clay, asbestos-cement and sheet metal. There are many designs, from the single louvre or sugar loaf, to the multiple louvre. Other types have a Venturi action, which draws air up the inlets on one side over the top of the pot and down outlets on the other side. Some of these are effective in difficult cases.

Hoods, made in burnt clay. A cap over the top of the pot is supposed to prevent air from blowing down the chimney. This is not always effective, as a diagonal downward gust of air enters the openings at the sides and blows down the chimney.

Revolving Cowls (Fig. 3 D), made in sheet metal. The wind blows the louvred cowl round so that it acts as an exhaust fan, drawing the smoke out. This type is often effective in bad cases. The shape is ugly.

No definite opinion can be expressed as to the effectiveness of any particular type. Everything depends on the local circumstances. Such a pot or cowl should not be fixed until any obvious defects in the fireplace or chimney have been remedied.

Old Fireplaces.—In many old houses and cottages large open fireplaces are found. In some cases the flues are 18 in. square or more. Some of these fireplaces and flues suffer badly from down-draught. Even in new buildings open fireplaces of the old-fashioned type are sometimes built. These consist of an opening the full width between the jambs with a dog

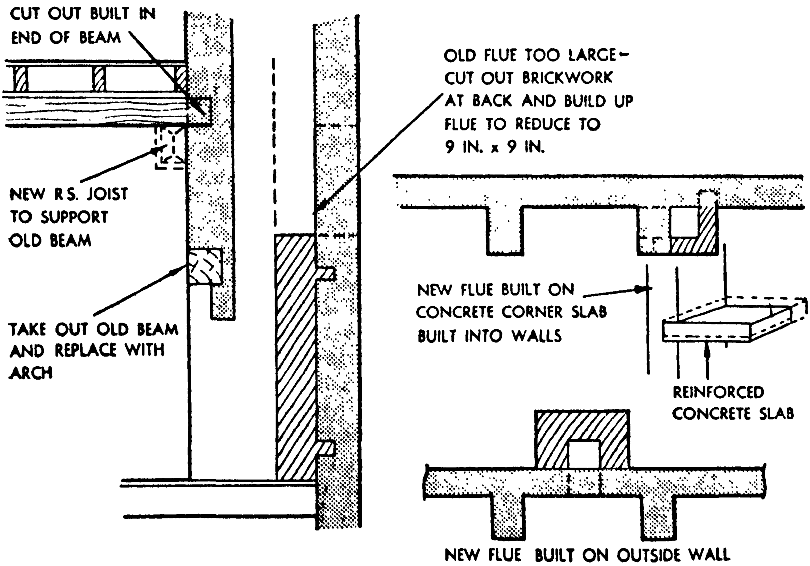


Fig. 4. (*Left*) Section showing how to reduce size of old flue and how to remove old timber beams built into flue wall. (*Right*) Two plans showing methods of building a new flue to replace an old one which has become faulty.

grate placed therein. Any down-draught is usually due to the design of the fireplace.

The fact is that such fireplaces are basically wrong, and the only remedy is to fix a modern type and build up the fireplace to the required width and shape, as shown in Fig. 4.

Large flues should be restricted in size by taking out the walling material and lining the flue with brickwork. Fireclay flue liners, as already described, are recommended. Old timber beams built into flue walls should be removed as indicated in Fig. 4.

Coring Flues.—A flue should be left with the interior free from all debris and droppings which may have become lodged against the sides during the work of construction or repair. During construction or repair of any but very short chimneys it is advisable to rest boards across the flue at suitable levels. It will be necessary to leave openings in the side of the flue so that the boards can be removed. On completion the opening should be made good.

Nevertheless, a certain amount of pargetting material or mortar will collect in the flue. This can be removed by *coring*. A sack filled with shavings or other suitable material is tied to the end of a line which has been previously let down the chimney from the top to a fireplace opening. The sack is then drawn up to the top, and as it rubs against the flue lining it removes mortar adhering to the lining and bits of loose debris resting in bends.

Large pieces of debris which may have been left in the flue through carelessness may be removed by rodding with a scraper or screw. If this is ineffective it will be necessary to measure the position of the obstruction and then open the side of the flue, as previously described.

Fireproofing.—Building by-laws (see Chapter 19) include a number of requirements designed to prevent the heat from flues setting fire to woodwork. In repair work these regulations should be carefully observed, but the work is sometimes left in a dangerous condition through carelessness or ignorance.

In old buildings it is often found that woodwork is much too close to the flue interior for safety, as already described. With the decay of the flue lining and brickwork, there is danger of fire.

By-Law Requirements

Briefly the by-laws require that: The chimney-breast and material surrounding the flues must not be less than 4 in. thick and must be pargetted or lined inside. The outside face of such chimney-breasts or flues must be rendered where they are less than 2 in. from any timber or woodwork, unless the breast or flues are at least 8½ in. thick. Chimney jambs must be at least 8½ in. wide on each side of the opening.

If the chimney-breast projects more than 4½ in. from the wall and the jamb on each side is less than 13 in. wide, the abutments of the fireplace arch must be tied in by a bar of wrought iron or steel built in 9 in. each side, and with ends split and turned up and down.

A fireplace back on an external wall or between two fireplaces built back-to-back (but not in a party wall) must be at least 4 in. thick. In all other positions it should be at least 8½ in. thick. In practice it is desirable that the

8½-in. minimum should be kept to for the sake of good insulation. The required thickness of fireplace back should extend at least 12 in. above the opening, and in the case of a kitchen for at least 9 ft. from hearth level.

If the course of a flue is bent so that the angle to the horizontal is less than 45 deg., the upper side must be at least 8½ in. thick. Chimneys must be carried up in material at least 4 in. thick to a height of not less than 3 ft. above the roof, flat or gutter adjoining thereto, measured at the highest point in the line of junction with such roof. The height of a chimney above the roof, flat or gutter should not exceed six times the least width of the chimney. (This does not apply to a tall industrial chimney.)

Timber may not be built into any wall or chimney-breast nearer than 9 in. to the inside of the flue or fireplace, nor under a fireplace within 10 in. from the upper surface of the hearth. A wooden plug may not be built into a chimney-breast nearer than 6 in. to the inside of a flue or chimney opening.

A hearth must be of incombustible material properly supported. It must be at least 6 in. thick, extend at least 6 in. at each end beyond the fireplace opening, and project at least 16 in. from the chimney-breast. The upper surface must be at or above floor level.

Checking Construction

When undertaking repairs to fireplaces and flues it is advisable to check the existing construction by the above requirements, and to call attention to anything which does not comply with such requirements. If anything of a dangerous nature is found, such as an old timber beam built into the chimney-breast close to the flue, the danger should be pointed out.

The above remarks apply to fireplaces and flues burning solid fuels. Typical sound practice is illustrated in Fig. 5. Gas-fire flues are dealt with in Chapter 9.

Types of Grate

Grates vary in type from the old-fashioned iron dog grate, which is simply an iron "basket" standing in the fireplace opening, to an elaborate combination grate.

The usual type for heating only, and burning coal, is an open grate, which may consist of a cast-iron stool bottom with a loose front fret with sliding vent; a firebrick back and sides (which is sometimes in three sections); and some form of surround (tile slab, marble, slate or brick). In addition, there is often a mantelpiece of wood. The hearth is usually covered with glazed tiles, which may be obtained in slab form, or with separate tiles for laying and a slab tile kerb to match.

In fixing, the space between the firebrick interior and the brickwork of the fireplace should be filled in solid with brickwork or concrete.

For repairing cracked fireclay backs and sides a special fire-resisting cement should be used. There are several good makes on the market which any builder's merchant will supply.

Instead of the cast-iron stool bottom and fret a dished fireclay bottom is frequently used. These should be very deep, otherwise when the coal is piled up it may fall across the hearth. Many of these dished bottoms are found to be quite unsatisfactory for this reason. The only possible remedy is to fix iron bars across the front.

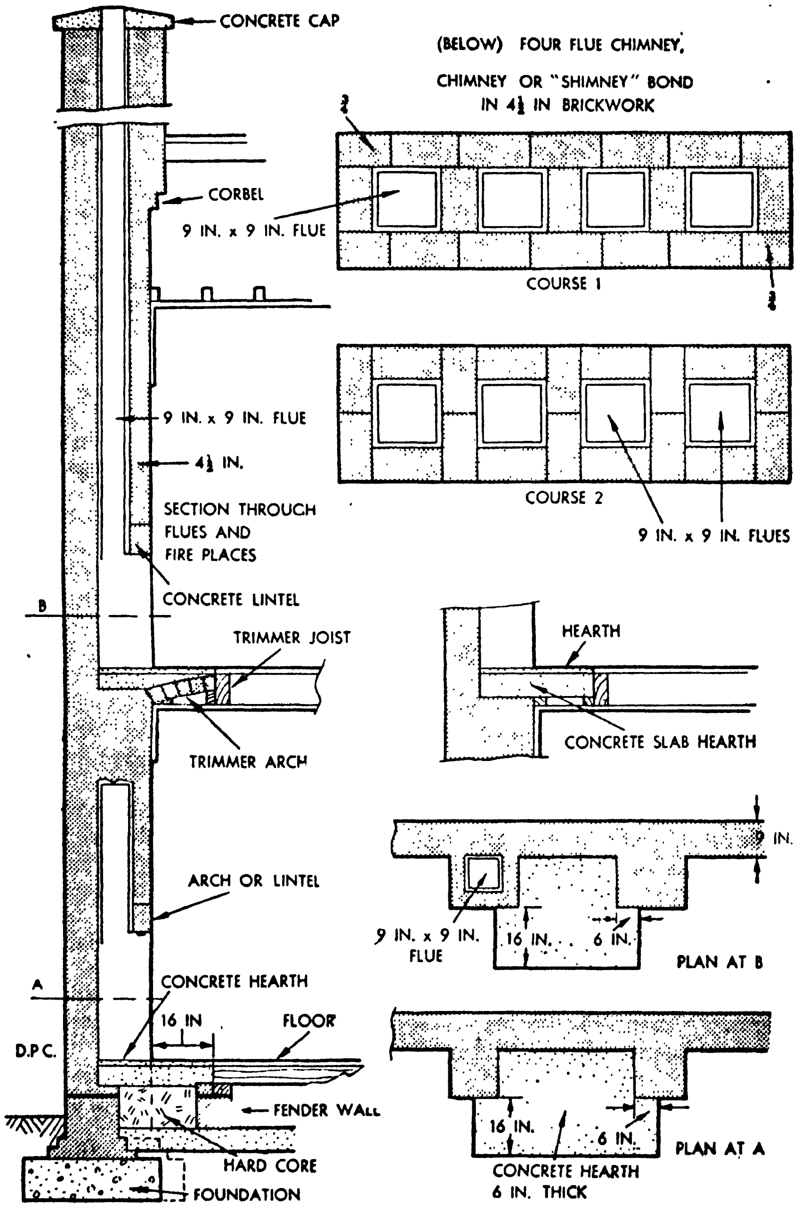


Fig. 5. Section and plans showing hearth and flue construction and indicating the various regulations which have to be complied with in accordance with by-law requirements. (*Top right*) Detail plans of chimney showing bond in 4½-in. brickwork. Note the hearth constructions on ground and first floors; for the latter the concrete slab is being increasingly used instead of the brick trimmer arch.

Register grates consist of a complete fire-grate unit, the interior, surround and mantel all being of cast iron; though fireclay is often used for the back and sides. They are cheap, and are often used in bedrooms in small houses.

Grate interiors with a back boiler are obtainable. In remodelling a house it is sometimes required to fix one of these grates in the dining-room or lounge. In appearance they differ but little from an ordinary grate. The heating of the water is controlled by a damper which directs the hot gases under the boiler.

A special type of grate is made for burning coke. This has a line of gas jets under the grate at the front. These jets are lit to start the fire and turned off when the coke is alight. The grate bars are of heat-resisting steel. It is a mistake to think that the fumes from gas-fired coke are any more dangerous than the fumes from coal. Both are dangerous if allowed to blow into the room. Where down-draught is absent no fumes can get into the room.

Combination Ranges are preferable to the old-fashioned kitchener range. A modern combination range usually has an oven at the side of the open fire, one or two hot closets, and a back boiler. In very small types the oven is frequently placed over the fire.

The flues in a combination range are rather small and complicated (Fig. 6). They run under the oven, up the fire side and over the top. A special damper controls the oven flue. The boiler flue runs under and behind the boiler and has its own damper. If these ranges are built in carefully according to the maker's instructions, and care is taken in making good the holes round the hot-water circulating pipes, they should give satisfactory service.

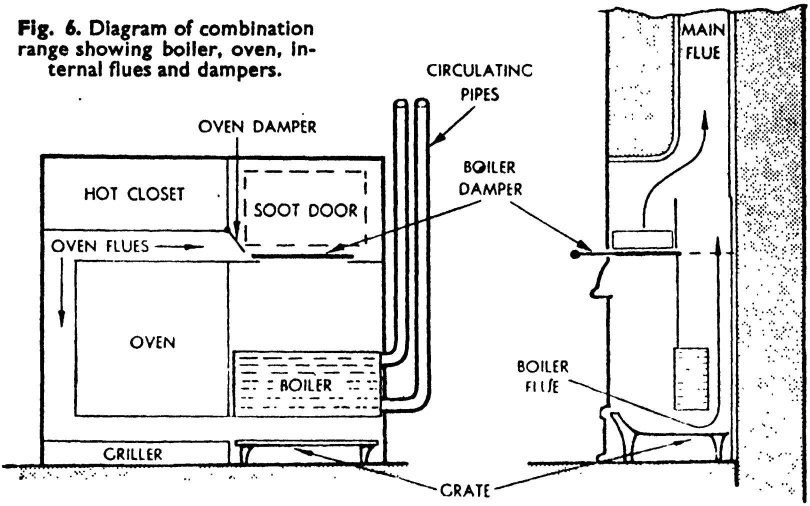
Faulty working is due either to faulty fixing, in which case check over everything according to the maker's instructions; or to blocked flues. It is important that the user should know how to work the dampers and keep the flues clean —a simple point, but trouble often arises from ignorance on the part of the user.

Portable Ranges are sometimes installed instead of the combination range. They are entirely self-contained, and can be fixed in a fireplace opening; in which case the flue outlet must be built solidly into the brickwork flue. They can also be connected to an iron pipe flue. The iron flue must be kept away from all woodwork and passed through the brick wall to a vertical sheet-iron chimney flue secured to the wall with holdfasts. The danger of such flues becoming overheated should not be overlooked. The chimney pipe must be secured with iron stays.

Portable Domestic Boilers are also made. They do not need a brick fireplace, and may be connected to a flue as described in the last paragraph. *Anthracite Stoves*, which are slow burning and need very little attention, can be placed in an existing fireplace or stood on a solid floor and connected to a flue.

Defects in Fires and Stoves.—Wear and fracture of the fireplace interior parts are common. Slight cracks in firebrick back and sides may be repaired with fireclay. There are various reliable brands of fire-resisting cement. Soot and loose material must be cleaned out of the crack before using the cement. At the same time the

Fig. 6. Diagram of combination range showing boiler, oven, internal flues and dampers.



edges of the firebrick back and sides should be pointed. Otherwise there is a tendency for cracked portions to move and reopen the cracks.

Where the firebrick is cracked right through it is advisable to replace with new back and sides if these can be obtained in the correct size. The Building Research Station state that "a serviceable fireback may be cast in concrete composed of crushed firebrick aggregate with high alumina cement". But it is hardly worth while making a special mould for one fireplace. The material might, however, be used in repairing wide cracks.

Make sure that the solid filling behind the fireback is in good condition. If necessary, take out the old fireback and build up the solid filling.

Cast-iron grates sometimes fracture. Usually it is best to replace with a new fitting of the correct shape, but any firm specialising in welded work will repair an iron grate at a moderate charge. This is useful if it is impossible to obtain a new grate or bars of the right size.

In repairing ranges and kitcheners all the internal oven and other flues must be traced and left in good condition and working order. New firebricks will be required for many of these repairs. These should be set in fire-resisting cement.

Steel Grates

Coke fires tend to damage and fracture cast-iron grates. Where it is found that coke is largely used, the customer should be told this, and a special heat-resisting steel grate (designed for burning coke) should be recommended (Fig. 7).

Cast-iron soot doors may have to be fitted to flues to simplify sweeping. These are necessary where there are very sharp bends in the flue. Soot doors should be fitted on the outside wall face where possible.

Existing slow combustion stoves are often connected to the brick flue with a right-angled connection, and soot is liable to

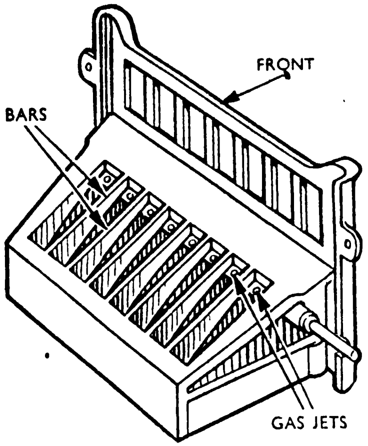


Fig. 7. Back view of a coke-burning grate which is provided with gas jets.

lodge at the junction, and block the flue. Although there is a cleaning cover on the cast-iron flue bend, this only enables the soot to be raked into the stove. It is advisable to fit an extension to the vertical flue with a soot tray and iron soot door, as shown in Fig. 8. The cast-iron smoke pipe must not be allowed to project into the brick flue.

Where the owner is dissatisfied with the functioning of the grate or range, the reason may be that the fitting, though working properly, is not suitable for the purpose. The repairer should consider this point and suggest an appropriate new fitting. In houses of moderate size, for example, one often finds boilers for heating bath and sink water that are not of adequate capacity for the demand; in such cases it is an economy to replace by a new boiler with a capacity which is in excess of requirements, but which need not be fully stoked.

Cost of Heating.—The repairer is frequently consulted about the relative cost of various heating sources. The following approximate figures will enable a general comparison to be made, taking an open coal fire as the standard:

	Relative Cost.
Coal Fire (open) . .	1
Coke Fire (open) . .	$\frac{3}{4}$
Closed Anthracite Stove .	$\frac{3}{4}$
Gas Fire (fixed) . .	$2\frac{1}{2}$
Electric Fire (1*d.* unit) .	4
Oil Stoves . . .	$1\frac{1}{4}$

It will be seen that coke grates and anthracite stoves are the cheapest to run. Electricity for heating in some cases costs only $\frac{1}{2}$d. unit, which is just half the above figure.

In recent years much attention has been given to the heat insulation qualities of the walls and roofs of buildings in order to economise in the cost of fuel. It is economical in the long run to spend a little more when building or repairing to ensure good thermal insulation and thus lower heating costs over a good many years.

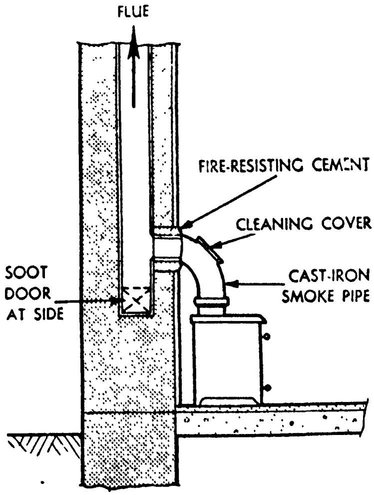


Fig. 8. Section showing junction of cast-iron smoke pipe to brick flue.

CHAPTER 8

DRAINAGE

SINGLE DRAINS. VENTILATION. DUAL AND COMBINED DRAINS. INTERCEPTING TRAPS. INSPECTION CHAMBERS. GULLEYS. RODDING EYES. JOINTING. LAYING DRAINS. SETTING OUT FALLS. DEFECTS AND REPAIRS. TESTING FOR LEAKS. DETECTION AND REMOVAL OF OBSTRUCTIONS. ALTERATIONS. TREATMENT OF OLD DRAINS. FLOODING. SEWAGE DISPOSAL. CESSPOOLS.

BEFORE undertaking the repair or replacement of existing drains, the principles underlying sound practice should be studied. The drainage points of a building are of two kinds: foul water and surface water. Foul water points include w.c.'s, urinals, slop sinks, kitchen sinks, lavatory basins and baths. Surface water is rainwater drained from roofs and from paved yards and roads. Usually both foul and surface water are drained into one sewer, but in some districts there are separate foul- and surface-water sewers.

Foul-Water Drains

Where there is no public sewer, foul-water drains (f.w.d.) are connected either to a cesspool or a septic tank. The cesspool is emptied at intervals—usually by the local authority. A septic tank leaves a clean effluent which can be run into the land. This system is illustrated in Fig. 1. Surface-water drains (s.w.d.) are separate, and are drained into sumps or tanks, as shown.

In the *Single Drain* system both foul- and surface-water points are connected to one drain and sewer. A typical example as applied to a small house is illustrated in Fig. 1.

Ventilation.—All drains must be ventilated. This is usually done by fixing a fresh-air inlet at the lowest part of the drain (where it passes through the boundary of the property to connect with the sewer), and a vent-pipe outlet at the highest point of the drain. These two positions are shown in the single drain plan which is shown in Fig. 1.

Construction of Air Inlet

The fresh air inlet (f.a.i.) may consist of an air brick or a metal fitting with a grating and flap. The flap allows air to enter, but prevents reversal of the air current. The f.a.i. should be fixed about 1 ft. above ground, and should be protected with brickwork or concrete. It is sometimes built into a boundary wall.

The vent pipe which is found at the head of the drain is usually an extension of an upstairs w.c. soil pipe. A wire globe or special vent terminal should be fixed to the top.

Drain pipes are usually of glazed stoneware, but cast-iron pipes specially protected against corrosion are often used, and are better, as they are stronger and, being in longer lengths, have fewer joints. For houses and other small buildings the pipes should be 4 in. internal diameter. In larger build-

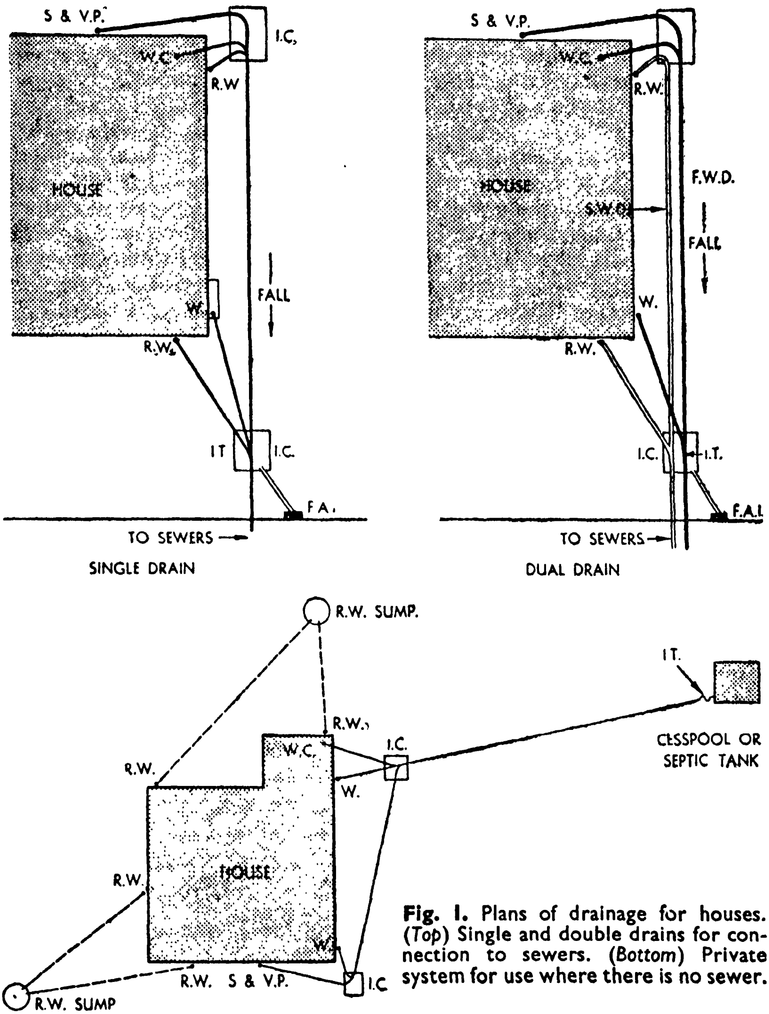


Fig. I. Plans of drainage for houses. (*Top*) Single and double drains for connection to sewers. (*Bottom*) Private system for use where there is no sewer.

ings it is very infrequently found necessary to use pipes of more than 6 in. internal diameter.

Drains must be laid in straight regular falls towards the sewer. Inspection chambers should be arranged at sharp bends, and the various connections should be grouped to connect with the drain at inspection chambers, as shown in Figs. 1 and 2. The various fittings will be described later.

The *Dual Drain* system is employed where there are separate foul- and surface-water sewers. A typical example is illustrated in Fig. 1. The main line of drainage along the side of the house consists of a double line of drainage pipes a few inches apart, both of which

run through the same inspection chambers. The w.c.'s, kitchen sink, and bath and lavatory wastes are run into the f.w.d., and the rainwater from the roof is run into the s.w.d.

In some districts half the surface water is connected to the f.w.d. and half to the s.w.d. It is obviously important to know exactly what system is required before undertaking alterations or replacement. The local surveyor or sanitary inspector will give the required information, and also the positions and depths of sewers.

Combined Drains

In the *Combined Drain* system a number of houses or other buildings share a common drain, so that only one connection to the sewer is required. A typical example is illustrated in Fig. 2A. This is a plan showing four houses connected to the sewer in one road, the drain running along the backs of the houses; and two houses connected to the sewer in another road. Not more than six houses or separate buildings may be connected through one combined drain. Connections should be grouped and brought into inspection chambers, as shown. The ventilation of the drain should be as previously described, but in most cases the local authority requires a vent pipe to each house.

Intercepting Trap.—In order to prevent offensive smells rising from sewers and drains, traps are fixed at various points. A trap may be described as a downward bend in a drain. Water remains in the bend and seals the trap, so that foul gases cannot pass through it. The bend at the foot of a w.c. pan is a trap which prevents offensive smells rising from the soil pipe and drains through the w.c. pan.

An intercepting trap is fixed at the lowest point of the drain where it crosses the boundary of the property to run down to the sewer. The trap prevents sewer gas from rising into the private drains. In Fig. 3 a section through an intercepting trap and inspection chamber is shown. An intercepting trap has a rodding or inspection arm rising from the sewer side of the

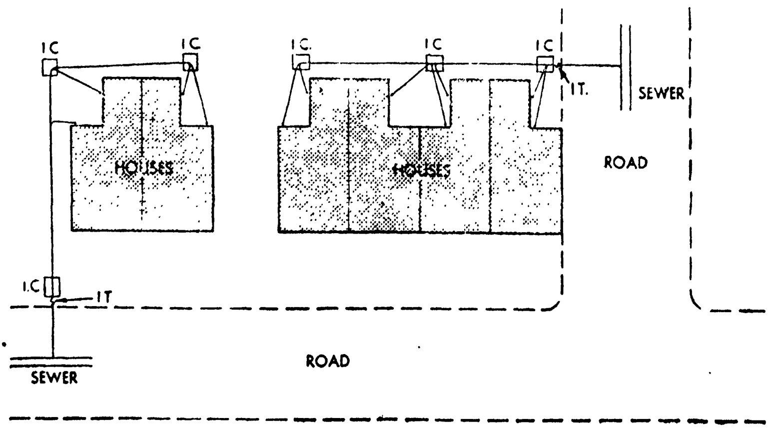


Fig. 2a. Plan of combined drains in which a number of houses or other buildings share a common drain, thus necessitating only one connection to the sewer.

drain. By this means the portion of the drain running under the road to the sewer connection can be inspected and any obstruction cleared by rodding. This inspection or rodding arm is covered at

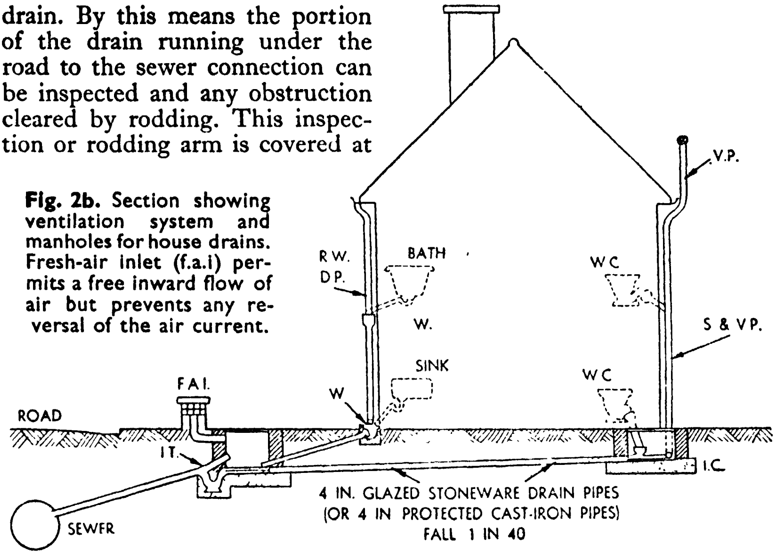


Fig. 2b. Section showing ventilation system and manholes for house drains. Fresh-air inlet (f.a.i) permits a free inward flow of air but prevents any reversal of the air current.

the end by a sealed cover which can be easily removed. The intercepting trap is made of the same material as the drain pipes—glazed stoneware or cast iron.

Inspection Chambers

An *Inspection Chamber or Manhole* is a brick chamber, rectangular on plan, with a removable iron cover. Its purpose is to afford ready access to the drain for inspection and rodding. The floor of the inspection chamber is of cement concrete. The drainage lines or bends within the inspection chamber are open, half-round channels. Thus the pipes connected to the chamber have open ends, so that the drains can be inspected or rodded. The floor around the channels is benched with fine concrete. This benching is shaped to a slope or fall from the walls of the chamber to the channels. Benching prevents any overflow remaining on the floor of the chamber.

As already explained, the connections from the various drainage points should be grouped, and inspection chambers so arranged that a number of points can be conveniently connected to each inspection chamber. The drainage line between inspection chambers should be straight if possible. But bends changing direction by not more than 45 deg. are permissible between inspection chambers, if they cannot be avoided. The object of arranging inspection chambers and limiting bends in the drain pipes is to allow the drains to be easily inspected and rodded to remove obstructions or trace defects.

Connections to Chamber

The connections to an inspection chamber are made with half-round channel bends and junctions. These should curve into the chamber in the direction of the flow, and should be planned so that they do not greatly retard the flow. The section in Fig. 3 shows the construction of an

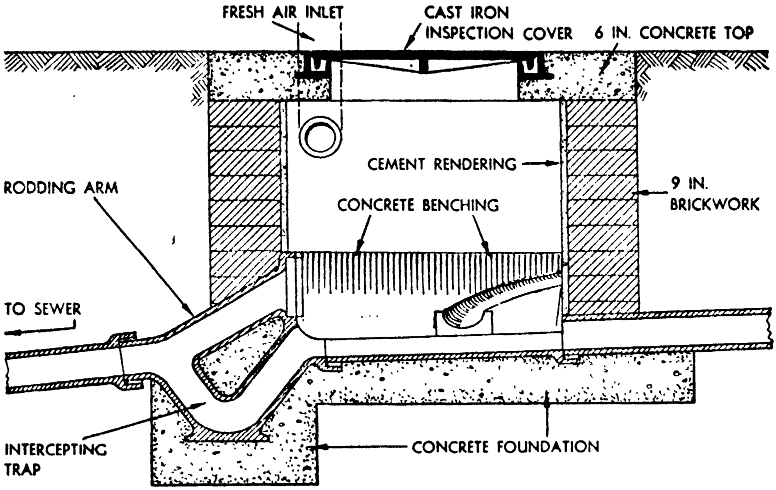


Fig. 3. Section through an interception trap and inspection chamber. The inspection arm rises from the sewer side of the drain, thus enabling the road section of the drain to be inspected and any obstruction removed by means of rodding.

inspection chamber with a 6-in. cement concrete floor and top, the 9-in. brick walls laid in cement mortar and rendered inside with cement and sand rendering, and the cast-iron inspection cover. This cover fits into grooves. The grooves should be filled with grease, which effectively seals the cover and makes it easily removable.

The chamber illustrated in Fig. 3 is built at the lowest point of the drain, and has the intercepting trap built into it, as already described. For this reason the chamber is commonly termed an intercepting or a disconnecting chamber. Ordinary (intermediate) inspection chambers have a plain pipe outlet. It will be noticed that in the section in Fig. 3 a fresh-air inlet is shown. This is a pipe bend brought up to a short inlet pipe which should terminate in an air brick or special flap inlet built into brickwork or concrete with a concrete slab top. The inlet should be a foot or two above ground. Fresh-air inlets are sometimes built into boundary walls.

In Fig. 2B the intercepting chamber is shown at the front and the inspection chamber at the back. This section indicates how the various connections are made to the chambers, and also how the air circulates through the drains from the fresh-air inlet to the vent pipe.

Gulley Traps

Gulleys are traps designed to disconnect the foul drain from a surface-water inlet. A common type of gulley is illustrated in Fig. 4 A. This is a glazed stoneware gulley with an iron grid. It is a type used under a rainwater pipe shoe. The iron grid is an inch or two below the top to prevent splashing.

A gulley for draining a yard has the grid flush with the top. Gulleys should have a flat bottom, and should be set on a 6-in. bed of

concrete, and the sides made up with concrete. A gulley under a rainwater or waste pipe should have a brick or concrete curb to prevent splashing.

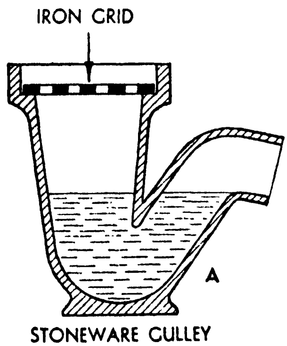
Some gulleys have separate round intakes into which the rainwater down pipe is jointed. In addition, the gulley may have an inspection or rodding cover on the drain side. There are a number of special gulleys and traps. That illustrated in Fig. 4 B is a grit gulley. It is useful in yards and private garages. Grit, sand and mud washed down into the gulley collect in the loose bucket, which should be periodically emptied. Special grease and petrol traps are made for commercial garages. The local authority should be consulted as to what type of gulley or trap for any special purpose will be approved. For trapping petrol in large garages a series of brick chambers may be required.

Rodding Eyes are removable covers at a pipe end or on top of a pipe. An eye may be used at the end of a short length of drain to save an inspection chamber, but owing to the fact that it is under the ground, the repairer who intends to rod the drain to remove an obstruction may not be aware that a rodding eye is available.

Jointing. — Glazed stoneware drain pipes have one end formed as a socket and the other as a spigot. In joining two pipes, the spigot end of one is fitted into the socket of the other, as shown in Fig. 5. The sockets should face up the drain so that the sewage flows *over* and not *into* the joint.

The joint is first lightly caulked by pressing in tarred gaskin or hemp—a piece of shaped wood or a special caulking tool is used for this purpose. The joint is then filled with cement mortar (not neat cement) composed of 1 part Portland cement to 2 parts sand. This is pressed in and left for about ten minutes when the edge is finished at a slope of 45 deg., as shown in the detail of plain spigot and socket joint in Fig. 5. It is most important that the gasket should be placed in position before the cement joint is made.

The purpose of the gasket is to



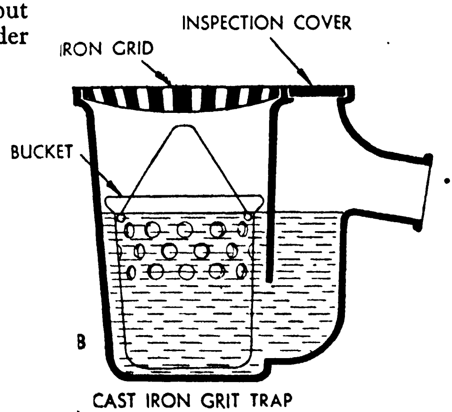


Fig. 4. A. Stoneware gulley trap for use under rainwater down pipe; B. special cast-iron trap for catching grit and mud. This type is useful for yards and private garages as the bucket can be removed and emptied periodically.

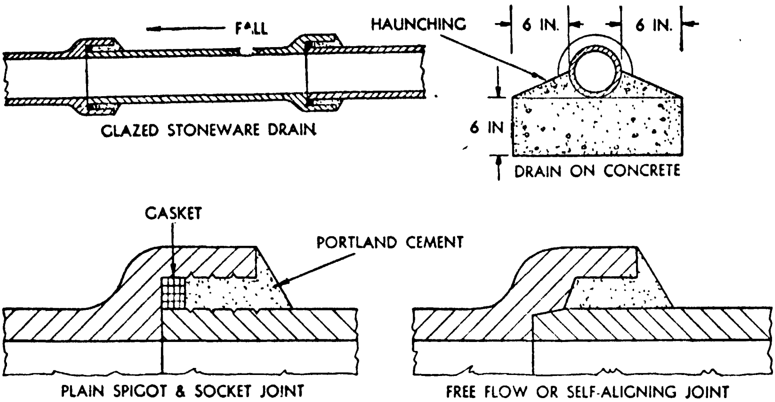


Fig. 5. Glazed stoneware drain pipes. Bottom section shows detail of plain spigot and socket joint, together with the patent "free flow" or self-aligning joint.

prevent the cement-mortar leaking through the joint into the drain. Even when a gasket is fitted, a little cement may find its way inside. This should be cleaned out with a raker, which is a circle of wood on a long handle. A ball of rags tied to a length of rope previously passed through the pipes is drawn through the drain on completion. It is essential that the interior of the drain is left clean and smooth.

The Portland cement-mortar should be mixed as required and used within twenty-five minutes of mixing. It should be fairly stiff, but thoroughly mixed. The joints should be covered with damp sacking to retard evaporation; this will prevent shrinkage and cracking. Cement joints exposed to hot sun rays will shrink and crack. The work must also be well protected from frost.

An alternative jointing material is a mixture of bitumen and sand boiled on the site and used hot. A mould of clay is necessary to hold the liquid in the joint until it sets. A bituminous joint is sometimes preferred, as it is slightly elastic and does not easily crack.

There are a number of patent pipe joints. A joint which is simple and has special merits is the "free-flow" or self-aligning joint, illustrated in Fig. 5. The socket is stepped and the spigot slightly bevelled to fit. This enables the gasket to be dispensed with, as the joint is cement tight.

Joints in cast-iron pipes are made either with tarred gaskin and molten lead, or lead wool well caulked into position. The lead wool joint is useful in repair work. Most repair work, however, is concerned with glazed stoneware drain pipes.

Foundations

Laying Drains.—Drain pipes must have a firm foundation, so that they cannot move, and also to prevent unequal settlement from taking place. On very firm ground the drain pipes may be laid direct on the trench bottom. On all other ground a bed of concrete 6 in. thick is required as a foundation, and this must be haunched up to half the diameter of the pipe, in the manner illustrated in Fig. 5.

Glazed stoneware drains laid under buildings must be entirely surrounded in cement concrete. This must be 6 in. thick all round. The concrete bottom should be level, and the top rounded over the pipes. Alternatively, cast-iron pipes may be used, jointed in lead, as previously described.

Drains should not be laid under buildings if this can be avoided. The runs under the buildings should be straight, and inspection chambers should be so arranged that the drains can easily be rodded.

Pegging the Trench.—The trench direction should be laid out with a line or by sighting rods into a straight line. Excavate to approximate falls, timbering the trench sides if necessary. In a long trench the boning-rod method is used for obtaining the correct fall, but for the short lengths required in repairs and extensions a straightedge and level can be used, as shown in Fig. 7. When the drains are to be concreted, pegs should be driven in the trench bottom along one edge of the foundation line.

Setting out Falls

If a straightedge is levelled with a spirit level, the fall can be set out from the lower edge. For example: if the fall is 1 in 40, a 10-ft. straightedge levelled will require a drop at one end of 3 in. to give the correct fall. Great care should be taken to avoid dips, by keeping the fall consistent throughout. The minimum fall for 4-in. drains is 1 in 40 and for 6-in. 1 in 60.

If the drains are concreted, the 6-in. foundation bed is laid to the fall as pegged, and the pipes are then laid. Concrete must be scooped out where the joints occur, so that the joints can be filled underneath. The space must be filled afterwards, and the haunching completed. On the trench bottom (without concrete) the earth must be scooped out under the joints (Fig. 6). The space under joints should be left unfilled until the drains are tested. This will allow any leaky joints to be seen at once, and defects can easily be remedied.

Defects and Repairs

The chief defects which are met with in laying drains are: (1) Leaky joints; (2) unequal settlement with (*a*) leaky joints or (*b*) fractured pipes; (3) cement and debris left in pipes causing obstruction; (4) obstruction through solid matter being washed down drains; (5) lack of proper ventilation; (6) bad smells through leaks, faulty fittings or blocked traps.

Leaks.—Old drains are almost certain to have leaky joints. Many old drains will be found to have clay joints; cement joints may shrink and crack. Movement of the ground through settlement or shrinkage may disturb the pipes and open the joints.

Where the drains generally are leaky the pipes must be taken apart and re-laid with new joints. This is a costly process, but it is essential if the joints are in a bad state. Patching the existing joints with cement is sufficient to stop very small leaks, but such small leaks in old drains are not likely to give trouble.

The opening of a joint through settlement of the drain is illustrated in Fig. 7. Another common joint fault is shown in Fig. 8 (*left*). The spigot tends to drop if the joint is carelessly made, and this may

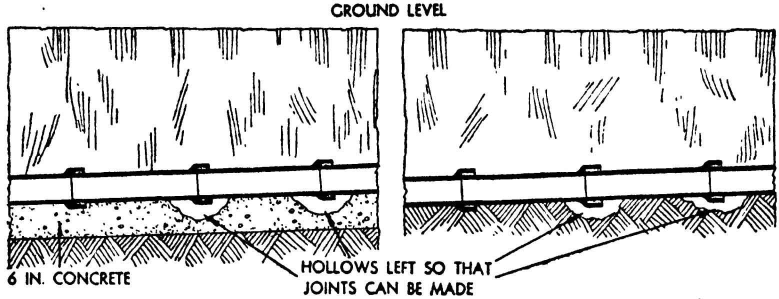


Fig. 6. Laying drains. To prevent movement and avoid unequal settlement the pipes are sometimes laid on a foundation of concrete 6 in. thick. The concrete is scooped out where the joints occur so that the joints can be filled underneath.

cause a great deal of trouble through leakage and obstruction.

A further fault of workmanship is also shown in Fig. 8 (*right*). This is a junction made by cementing the end of the branch pipe into a hole cut in the main drain. This is sometimes found where a 4-in. pipe joins a 6-in. It is very bad practice, and any such junctions should be taken up and a proper junction pipe fitted.

Causes of Fractures.—The conditions shown in Fig. 7 (*bottom*) give rise to bad leaks and obstructions. Fractures may be due to various causes such as unequal settlement of the ground, heavy traffic, or to a pipe being cracked after it has been laid. Fractures should not be patched; the pipe should be taken out and replaced with a new one.

Treatment of Fractures

The cause of the fracture must be found so as to prevent the trouble from recurring. In a road, for example, the cause may be the weight of lorries moving over it. It

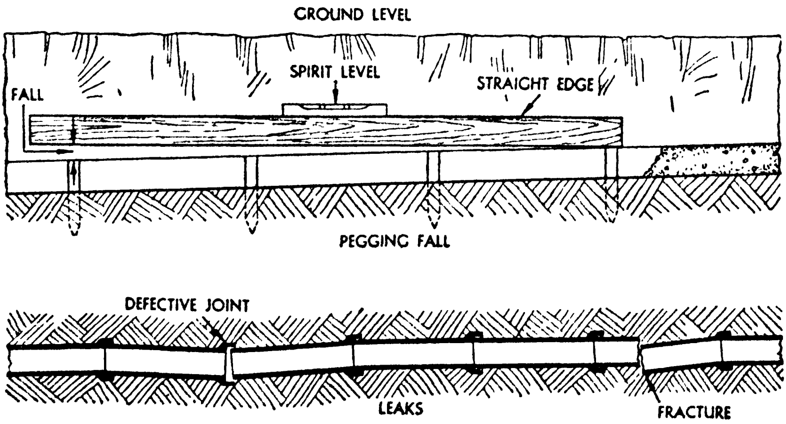
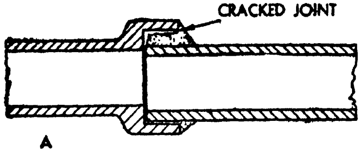


Fig. 7. (*Above*) Setting out the fall by means of straightedge and spirit level. (*Below*) Defects in stoneware drains may be due to unequal settlement of the ground, heavy traffic or to the pipe being cracked after it has been laid.



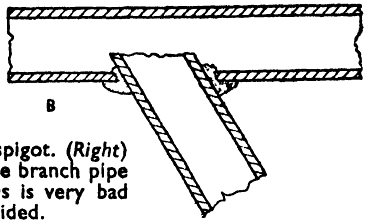


Fig. 8. (*Left*) Faulty joint due to dropped spigot. (*Right*) Junction made by cementing the end of the branch pipe into the hole cut in the main drain. This is very bad practice and should always be avoided.

may be necessary to pave with reinforced concrete in order to overcome this. In very weak ground it is necessary, as already described, to bed and haunch the drains in concrete. If defective drains are found in weak ground the new replacement drains should be so protected.

In such ground it is advisable to reinforce the concrete bed with expanded metal placed 1½ in. from the bottom of the concrete. This enables the whole drain to act as a bridge over weak patches of ground, or even over pockets which may result from settlement.

Testing for Leaks

There are four common methods of testing drains for leaks: the water test; the smoke test; the air test; the volatile oil test. The water test is often called the hydraulic test. It is a pressure test, as also is the air test. Smoke is applied under pressure, though the pressure is slight. The volatile oil test reveals leaks by the escape of a pungent-smelling odour given off by oil of peppermint or other suitable chemical. New drains are tested by the local authority before they are covered in, usually by means of the water test.

The best method for the building repairer of testing old drains, or drains which have just been repaired, is to stop the drain at the lowest point and fill with water at a higher point. This can usually be done by gaining access to the drain at the lowest inspection chamber and stopping the drain inlet with an expanding stopper (Fig. 9). By turning the screw, a rubber tyre expands outwards and effectively stops the drain.

If it is desired to test a section of the drain between two inspection chambers, another stopper should be fitted to the inlet (or to each inlet if there are more than one) at the next inspection chamber higher up. These positions are shown in Fig. 10, which is a section through a portion of the drain. Now fill the higher inspection chamber with water and measure carefully the distance

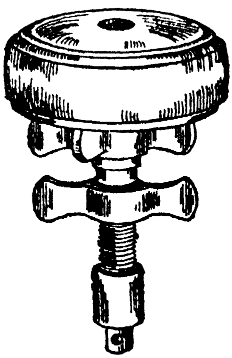


Fig. 9. Expanding drain stopper for carrying out tests on drains and pipes with water, smoke or air.

from the top of the cover frame to the top of the water. Leave for two hours, inspecting the lower stopper to see that there is no leakage at this point.

If the water level in the chamber goes down to any appreciable extent a leakage is indicated. There will be a slight lowering of the level even if the drains are watertight, due to absorption and possibly to some evaporation. If there is any doubt as to the leakage the drain must be emptied, by removing the lower stopper, and the test repeated. At the second test there should be practically no loss of water caused by absorption.

This is a pressure test. The pressure is proportional to the head (vertical height) of water, which should not exceed 6 ft. It is sometimes stated that a pressure test is not fair to old drains, as the pressure may force open the joints, but the test merely reproduces the conditions which occur when the drain is accidentally blocked, which may occur in any drain. So the pressure produced by this water test is not greater than may actually occur in normal use.

Branches from gulleys can be tested at the same time, provided the gulley trap is not below the level of the test water head. Some air may be caught at the top of the trap bend. This should be removed by inserting a short piece of rubber tube and sucking the air out. It is usually convenient, however, to test each length and branch separately.

If the ground is open, any leaks will be revealed by inspection. If the drains are covered (as in testing old drains), the shorter the lengths tested at one time the better, as then the job of opening the ground and searching for leaks can be confined to those sections in which leaks are indicated by the test.

Smoke Test

The *Smoke Test* may be applied in two ways. One is by inserting a smoke rocket after stopping the outlets. This is quite good for short lengths of drain where the ground is open and the joints can be seen, but useless for long lengths or covered drains, as the pressure is very slight.

The second method is to use a smoke-generating machine, which consists of a container in which a smoke-producing material, such as oily cotton waste, is burnt and a hand-worked bellows used to drive the smoke into the drains. The smoke pipe is connected to the drain through an expanding stopper fitted with a suitable inlet. Any leaks are indicated by the escape of smoke.

This is quite a good test, but it is not reliable in the case of deeply

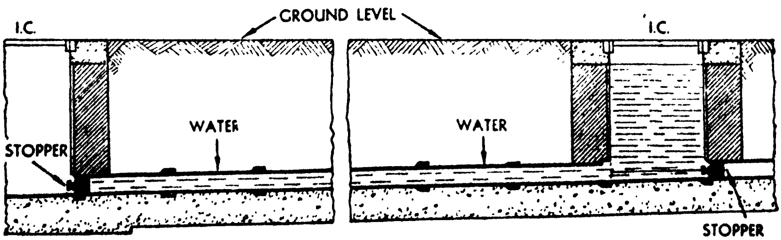
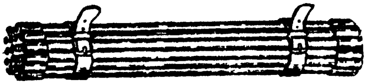
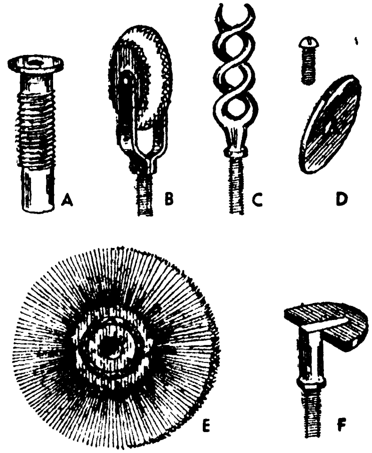


Fig. 10. Water test applied to section of drain between two inspection chambers





Figs. 11 and 12. (*Left*) Flexible rods which are employed for cleaning drains and removing obstructions. (*Right*) Selection of tools for use with rods. *A.* brass bush; *B.* roller; *C.* double worm; *D.* rubber plunger; *E.* brush; *F.* scraper.

covered drains, as the smoke may not rise through the ground. If applied to covered drains, an iron rod should be used to probe the ground at short intervals along the drainage line. This will enable smoke to escape if there is any leakage.

The *Volatile Oil Test* is not suitable for testing underground drains, but is quite a good test for soil and waste pipes and fittings. Place about 6 oz. of oil of peppermint in a bucketful of boiling water and pour down the highest w.c. trap in the system. This should be done by an assistant, so that the person making the inspection will not carry the smell of the peppermint. The latter can then walk over the building sniffing round the joints of pipes and fittings. The pungent smell of peppermint will readily be detected if it leaks through a defective joint.

Chemical Testers

Special chemical drain testers are made for testing by smell. These are small containers holding a pungent chemical, which are dropped into the trap and flushed through with hot water. The container then opens and releases the pungent chemical.

Obstructions in a drain are indicated by the overflowing of traps and other fittings. The obstruction may be in the trap itself or some distance away down the drain. A spiral spring rod may be used to push through a w.c. or gulley trap. This will detect any obstruction at this point, and may enable it to be cleared.

If the obstruction is in the drains, the inspection chambers must first be opened. The drain length between two inspection chambers may be inspected by placing an electric torch at one end of a straight length of drain, and fixing a small mirror at a suitable angle near the other end. By means of the mirror the interior of the drain will be clearly seen if it is unobstructed. Other defects, such as fractures, can be detected by this method. With a strong light it is possible for the light to pass round a slight bend, so that the whole length can be seen by reversing the lamp and mirror positions.

Cleaning Rods. — Obstructions can usually be cleared by using cleaning-tools on the end of rods. A set of rods and tools is shown in Figs. 11 and 12. The rods are flexible and can pass round bends. The fittings are: *A*, brass bush; *B*, roller; *C*, double worm; *D*, rubber

plunger; *E*, brush; *F*, scraper. The double worm and scraper are the two fittings most effective in removing obstructions. By revolving the rod the double worm will break up most obstructions.

If the obstruction cannot be removed by rodding, the length of rod can be used as a measure to give the position of the obstruction, this measurement being then set out over the drain. The point can then be opened and the pipe taken up to clear the obstruction. It will be found necessary to disturb three or four pipes. The old jointing material should be removed and the pipes relayed with new joints.

Flooding.—In certain positions drains may be liable to occasional flooding, and the consequences may be serious. Flooding occurs when the drains overflow during exceptionally heavy rain of such volume that the sewers cannot take it away fast enough. An anti-flooding ball valve interceptor can be fitted to the drain to prevent this trouble. It is easy to understand how, as the water rises in the drain, the ball is forced against the valve seating, and so prevents water rising beyond this point. There is one disadvantage with such a fitting. If a considerable head of water is developed, the pressure in the drain may be excessive, and in an old drain may burst the joints.

Sewage Disposal.—Where there is no public sewer the foul drains must be connected either to a cesspool or a septic tank. The rain and surface water can be drained into soak-aways, sumps, or ditches, though surface water from slate or other chemically stable roofings can be filtered for domestic use.

A *Cesspool* is merely a brick or concrete tank for storing sewage until it can be emptied. It is satisfactory provided that the local authority undertakes to empty it periodically. In many districts this is done with mechanical vehicles.

The plan of a cesspool may be circular or square. Walls are of (*a*) 9-in. brickwork in cement-mortar rendered inside with cement and sand backed with 9-in. clay puddle, or (*b*) 6-in. cement-concrete. Walls must be built on a cement-concrete bottom not less than 6 in. thick. The top may be arched or domed in brickwork or covered with a 6-in. reinforced-concrete slab. A cast-iron inspection and access cover and an air vent pipe should be provided. The capacity should be at least one month's normal sewage. The local surveyor should always be consulted in regard to the construction.

Repairs to Cesspools

In repairing old cesspools, the work usually consists of thoroughly cleaning out, and then hacking the interior wall face and rendering in cement and sand. The rendering should be waterproofed. The bottom should also be rendered, and rendering should be continued under the dome. A new cast-iron access cover may be required to replace an existing stone slab cover. In some cases the dome brickwork may be badly decayed. It should be removed, and it may be more convenient to build up the walls and cover with a reinforced-concrete slab. A new vent pipe may be required. A cesspool must be placed not less than 50 ft. from a dwelling and not less than 60 ft. from a spring or well, and it must be disconnected from the drains by fitting an interceptor trap and chamber.

CHAPTER 9

GAS AND ELECTRICITY

GAS

MANUFACTURE AND STORAGE. MAINS AND SERVICES. FLOW AND PRESSURE CARCASSING. PIPE LAYING. FIRE AND COOKER SUPPLY. GENERAL SAFETY RULES. TESTING UP. PRESSURE GAUGES. LOCATION OF STOPPAGES. DETECTION AND REPAIR OF LEAKAGES. FLUES. TYPES OF RADIANTS. METERS.

It is rather a trite saying that you cannot get more gas out of a pipe than can be put into it, yet this is the most persistently ignored rule.

On every hand cases are met with in existing gas installations of pipes being expected to give adequate service to apparatus requiring two or three times the amount for efficient use. Much damage to the reputation of well-known appliances can be caused through neglect of this simple fact. However, it is satisfactory to note that there now exists a tendency to pay more attention to this important aspect of gas supply.

Only a few simple tools are necessary to tackle most of the fitting and repair jobs likely to be encountered in the home or small factory. One exception to this, however, is the fixing of hot-water appliances. A certain amount of theory will be necessary, but this is kept to the minimum, and limited almost to the principle mentioned in the opening paragraph.

Towns Gas, which is the name of the particular commodity dealt with in this chapter, possesses characteristics which are common to most gases. This gas is a distillate of coal which is heated without air in a closed retort to such a temperature as will drive off certain elements in the form of gas. This gas when leaving the retort is very mixed and quite unsuitable for sale to the public until it has passed through numerous stages of purification. These purifying processes rid it of valuable by-products which are again purified and treated to provide the almost bewildering number of commodities now in commercial use. The principal by-products are tar, ammonia, sulphur and coke.

Towns gas is very light and highly inflammable. Mixed with air in certain proportions it becomes explosive, but in proper proportions and suitably controlled, the mixture provides for nearly all the operations in which it is used.

After purification gas is passed into the familiar storage tanks called gasholders, not gasometers, from whence it is transferred to the supply area through the medium of the Station Governors into the Mains. The function of the governors is to maintain a steady pressure.

Mains vary greatly in size; some as large as 48 in. and others as small as 3 in. Except where the

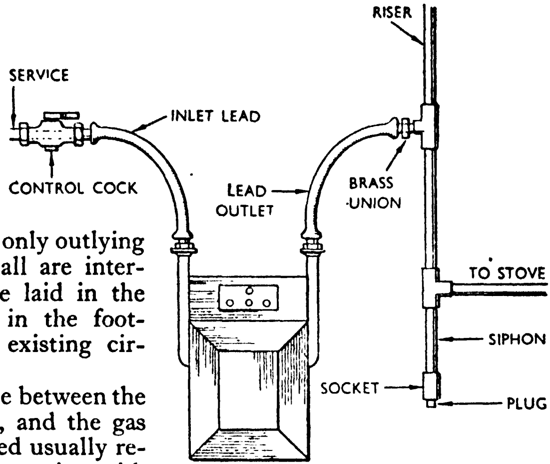


Fig. 1. Simple arrangement of service and meter connections showing gas passing through control cock before entering meter.

very large ones serve only outlying or special districts, all are interconnected. Some are laid in the roadway and some in the footpaths, according to existing circumstances.

A service is the pipe between the main and the meter, and the gas undertaking concerned usually retains all rights in connection with it. The concern of this chapter will be, therefore, with internal fitting, beginning with the meter outlet union, which is on the right-hand side, except in a few special cases. These are always clearly so marked.

Alterations and Additions

It can be accepted as a general rule that any fitter may add to or alter metered supplies except where the installation is the property of the gas company, as is the case with many slot-meter installations. It is generally advisable to refer all cases of doubt to the particular undertaking concerned.

In no instance should additional appliances be installed without the company being notified, as in many cases a meter of larger capacity would be necessary. Failure to do this may result in a serious restriction of the supply through the existing meter being under size.

Apart from the carrying capacity of pipes, the only matter likely to cause concern to the fitter is pressure, but if the general rules concerning the former are observed the latter may with reasonable expectancy be referred to the gas company. Other matters relating to pressure will be dealt with as occasion arises.

Fig. 1 shows a simple illustration of service and meter connections. These are generally of lead, though there is at least one proprietary malleable iron connection which is at present obtainable.

It will be observed that the gas passes through a control cock just before entering the meter, and this cock must be turned off before any pipe containing gas is opened. On no account should the meter inlet be connected or disconnected except by arrangement with the supply company.

Piping and Fittings

It is assumed that the fitter already knows the elements of pipe threading, and the difference between taper and parallel threads. In any event, where he has to cut and thread pipe lengths he will naturally use the same dies, and should therefore see that his

connecting pieces are provided with suitable threads.

The internal piping of a house is called the carcass, and for this both composition and wrought-iron pipes are used. Connecting fittings, such as elbows, are often made of malleable iron. Compo pipe is easy to lay, as it can be bent around corners, but owing to the possibility of damage by nails or by sagging, it is not generally recommended, except perhaps for certain small and fairly unimportant jobs. Wrought-iron tubing is usually threaded with the British Standard pipe thread.

The small fittings in general use are the short, bend, spring, connector, elbow, tee, socket, plug, cap and nipple (stub or barrel). Crosses are occasionally used, and the connector is either single or double, with one or two backnuts accordingly. Unions of brass are, of course, necessary in many cases, and may be threaded in either iron or brass dimensions, according to size and use.

All the forementioned fittings are illustrated in Fig. 2, with sub-titles lettered, and it will be noticed that elbows, sockets and tees are both equal and reduced.

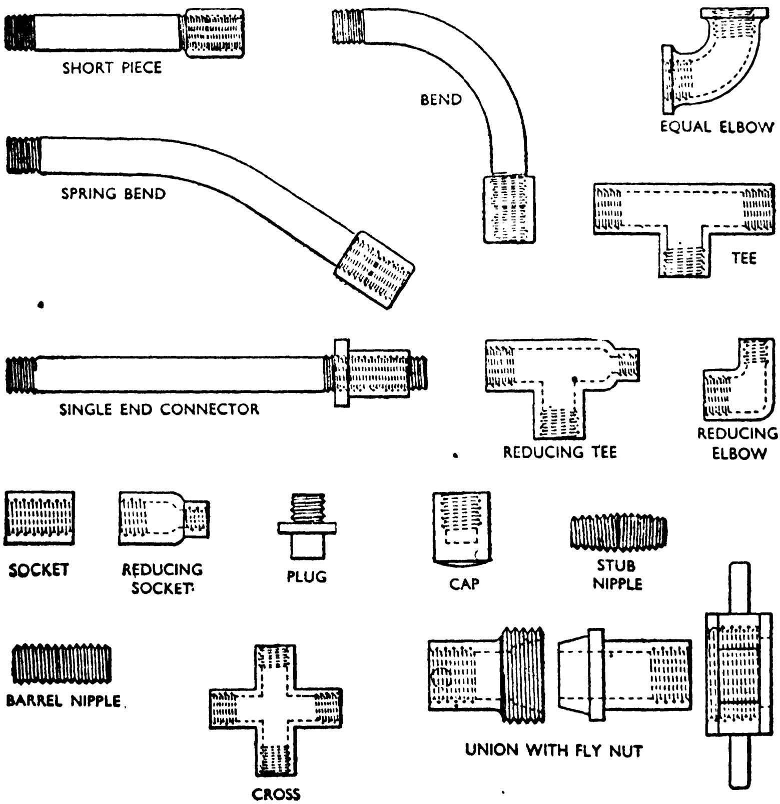


Fig. 2. Types of small fittings which are employed in internal domestic piping.

Without entering unduly into the theory of the flow of gas in pipes, there are certain simple rules governing the lengths of differing sizes of barrel which may safely be laid in order to be confident that the appliance will give satisfactory service. The reason for this is based very largely on the fact that statutory gas companies must maintain certain minimum pressures throughout their areas, and as it is known how much gas a pipe will carry without losing too much of the pressure, the following data have been evolved as a general standard:

$\frac{1}{4}$ in.: About 12 ft. maximum run.
$\frac{3}{8}$ in.: About 15–18 ft. maximum run.
$\frac{1}{2}$ in.: About 30 ft. maximum run.

The carrying capacity of $\frac{3}{4}$-in. pipe is considerable, being roughly twice that of $\frac{1}{2}$-in., and cases are not unknown of this size taking all the load required in a normal six-roomed house, with the smaller pipes running off it. For an appliance like a geyser, however, a limit of 50 ft. should be laid down.

Allowance must be made for loss of pressure caused by tees, bends and elbows, as these offer appreciable resistance to the steady flow of gas. The following data are suggested as a minimum standard from which to work. If this standard is observed, no trouble through bad supplies should be encountered over a very long period.

In all cases starting from the meter:

Cooker: $\frac{3}{4}$ in. If only a short run without branches, $\frac{1}{2}$ in.
Copper: $\frac{1}{2}$ in. to within 6 ft. or so, then $\frac{3}{8}$ in. Connections to coppers are usually $\frac{1}{4}$ in., and if the supply is good, the whole 6 ft. might be run in $\frac{1}{4}$ in.
Small sink heater: $\frac{1}{2}$ in. if not more than about 12 ft. run. If more, back up with $\frac{3}{4}$ in.

Two or three feet of the larger size should be allowed extra for every tee, elbow and bend necessary in the smaller sizes following.

Taking London as an example, it is interesting to examine a few typical suburban houses, and note how the carcassing has been done. It is possible almost to gauge the probable sized supplies in any of

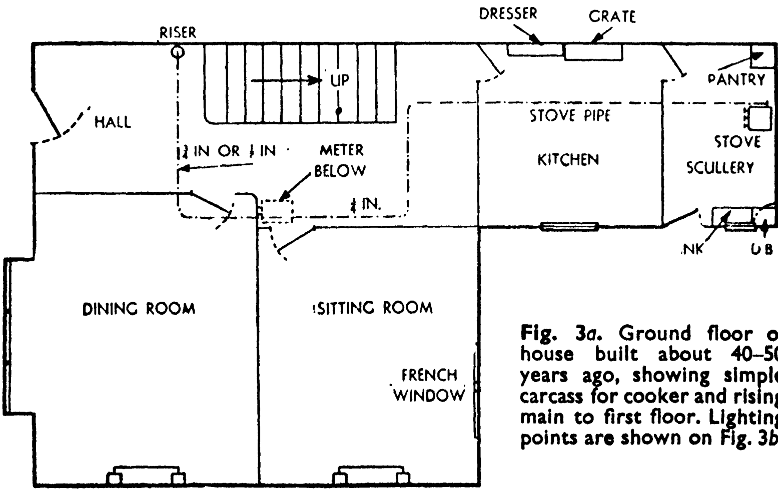


Fig. 3a. Ground floor of house built about 40–50 years ago, showing simple carcass for cooker and rising main to first floor. Lighting points are shown on Fig. 3b.

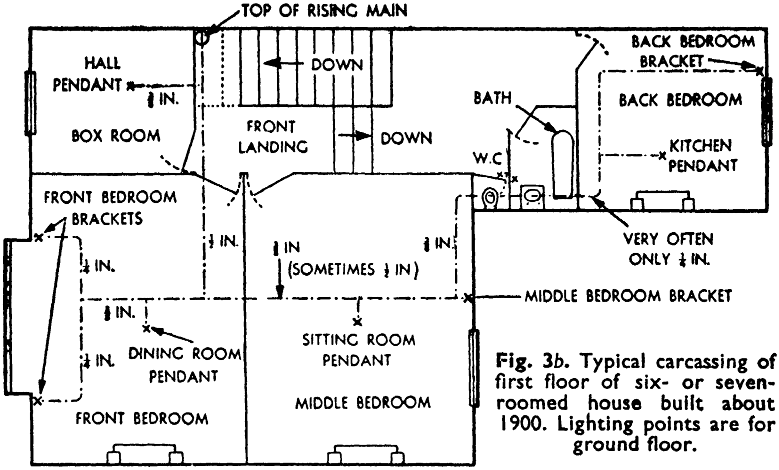


Fig. 3*b*. Typical carcassing of first floor of six- or seven-roomed house built about 1900. Lighting points are for ground floor.

these structures if the approximate age of the house is known, and this in turn may quite frequently be judged by the frontal elevation.

Figs. 3*a* and 3*b*, show a typical lay-out of the ground floor and first floor of a house which is 40–50 years old. This was probably carcassed only for cooking and lighting. It will be seen that the only positions provided for pendants were located in the dining-room, sitting-room, kitchen and hall, all the other points being brackets.

Those in the bedrooms took the familiar places on each side of the window in the front room, and either one side of the window or on the chimney breast nearest to the window in the other bedrooms.

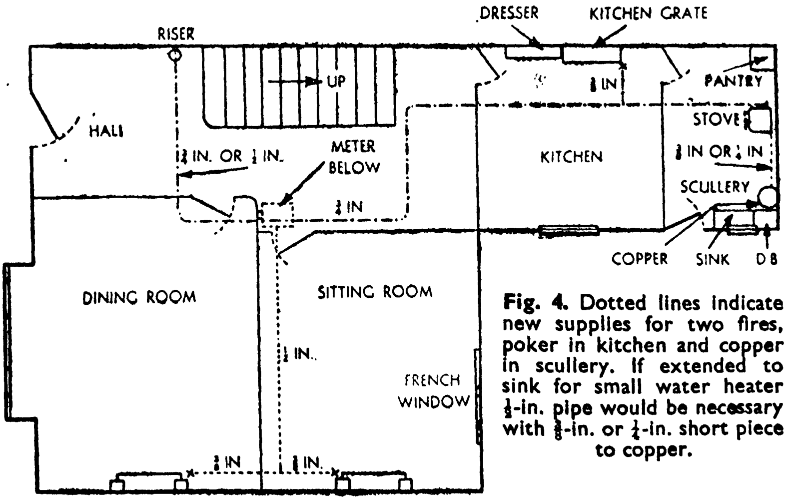


Fig. 4. Dotted lines indicate new supplies for two fires, poker in kitchen and copper in scullery. If extended to sink for small water heater $\frac{1}{2}$-in. pipe would be necessary with $\frac{3}{8}$-in. or $\frac{1}{4}$-in. short piece to copper.

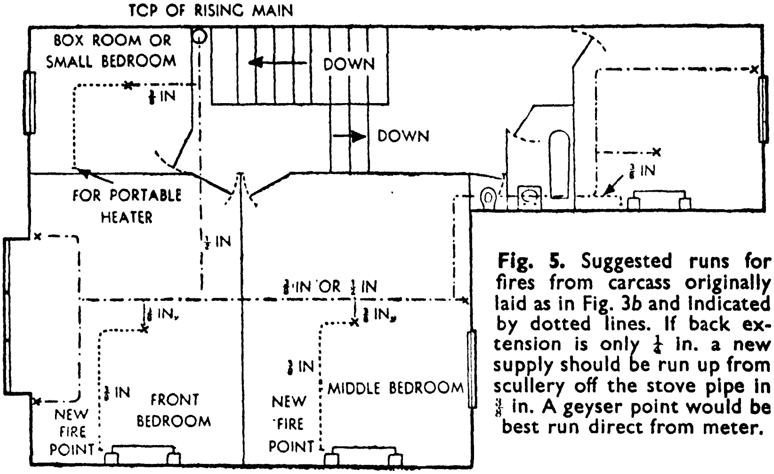


Fig. 5. Suggested runs for fires from carcass originally laid as in Fig. 3*b* and indicated by dotted lines. If back extension is only ¼ in. a new supply should be run up from scullery off the stove pipe in ⅜ in. A geyser point would be best run direct from meter.

In Figs. 4 and 5 the same house is shown with the gas copper and fire points added. These show pretty clearly the different way in which runs were taken, with resultant economy of pipe. They should not be taken as standard, since other considerations would in some cases necessitate the adoption of slightly different methods. They do, however, indicate a method of carcassing common to all districts.

Fig. 6 shows a house built about 1918. In this case all the lighting points were for pendants, which are shown in broken lines. The dotted lines show the method of laying additional points.

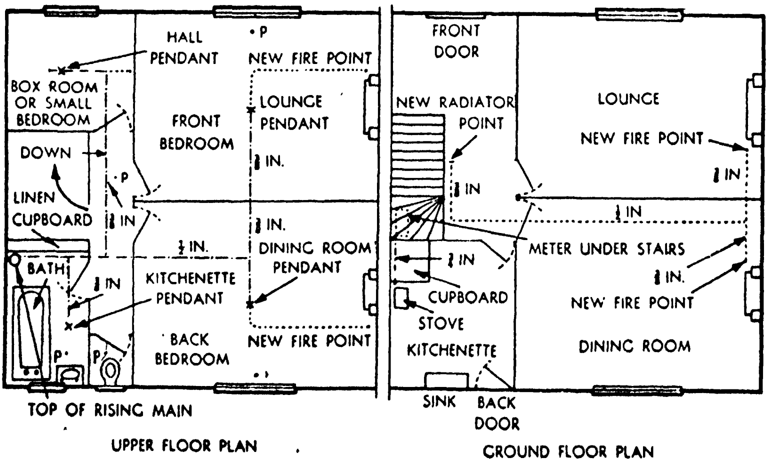
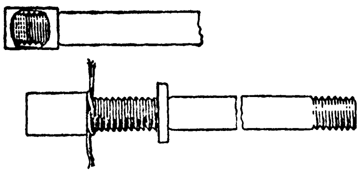


Fig. 6. Small house built about 1918, and carcassed for stove and lighting only. Dotted lines show how the runs for new appliances would be made. "P's" indicate the positions of lighting points for the first floor.



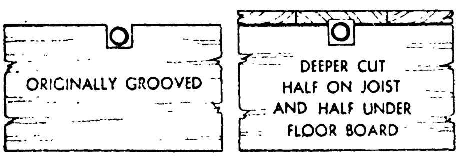
Figs. 7 and **8.** (*Top*) Pipe thread should be long enough only to screw half-way into the socket. (*Bottom*) Use of hempen twine for grummet.

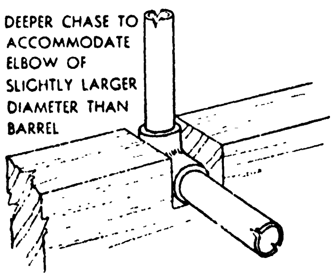
Before proceeding with any job, it is desirable to observe a few rules which will assist good work.

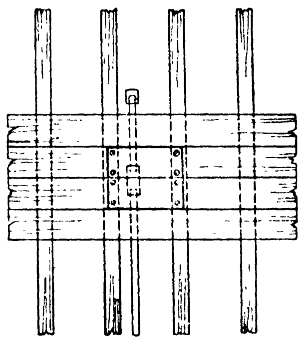
1. Ensure that pipe lengths are free from obstructions.
2. Test all threaded joints for easy fitting before screwing up.
3. Paint only male threads, using a good oxide paint.
4. Reverse sockets on pipe lengths, shorts and bends, but *not* on connectors.
5. Screw up sockets half-way only, so that whatever is fitted to the other end has equal support (Fig. 7).
6. Remember hempen twine for grummetts. Improvisation may be effected by unravelling thick brown string. Tie the knot once only as shown in Fig. 8.
7. Cut grooves in joists with care. They should be very slightly larger than the pipe they are intended to carry. If a change of direction necessitates an elbow on a joist, *then* cut a deeper groove (Figs. 9 and 10).
8. Replace floor boards with C.S. screws of adequate length, and remember to leave a trap over a pendant point (Fig. 11).
9. Support all barrel lengths alongside walls or joists with hooks or cleats as the case may be or require (Fig. 12).

If a long run must be made between joists, use a bridge piece. This is made with two cleats and a crosspiece (Fig. 13).

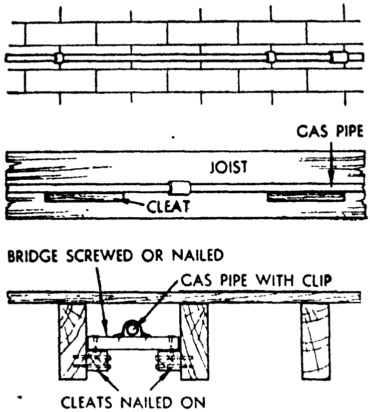
10. Use bends rather than elbows. Many fitters show great antipathy to bends, but they offer less resistance to the flow of gas.
11. Keep gas and electricity supplies as far apart as possible. If contact or very close proximity is unavoidable, insulate.
12. Always fix a control cock







Figs. 9, 10 and **11.** (*Left*) Cutting grooves in joists. Care should be taken to ensure that a trap is left over pendant point as in Fig. 11 (*right*). Pipe should be supported by bridge pieces.



Figs. 12 and 13. (*Above*) Use of hooks and cleats for supporting barrel lengths alongside walls or joists. (*Below*) Method of forming the bridge piece when a long run must be made between joists.

on a check meter inlet, and don't fix check meters on pipes served by automatic meters.

One of the principal things to be kept in mind is that gas contains water vapour, which condenses in the cold pipes and flows to the lowest possible level. Pipes should therefore be laid with a continuous fall back to some convenient point, the best being near the meter, though recourse has at times to be made to other positions.

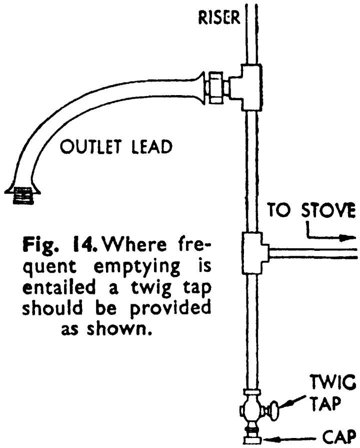


Fig. 14. Where frequent emptying is entailed a twig tap should be provided as shown.

In the latter event the insertion of a tee, with short piece, socket and plug, will facilitate easy drainage, and if this is underneath a floor, a trap must be left over the spot. This drainage length, which is actually a catchbox, is termed a siphon. A good example appears in Fig. 1 on the meter outlet. Where frequent emptying is found desirable, a good plan is to provide a twig tap, which should preferably be capped when not in use. This is shown in Fig. 14.

As running the supply for a gas fire is a light job, the heaviest

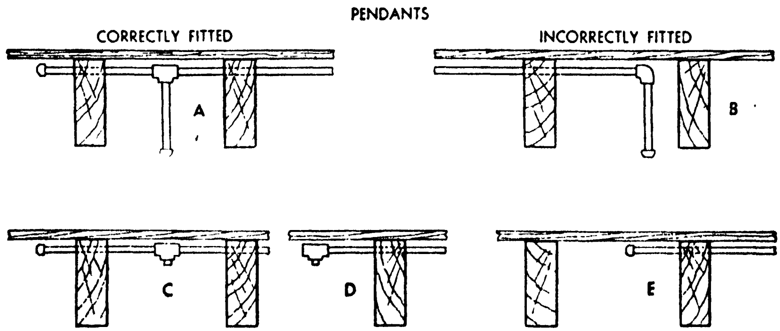


Fig. 15. Method of fixing pendants. A. Correct method; B. Incorrect method; C, D and E. difficulties which may be encountered where electricity has been installed.

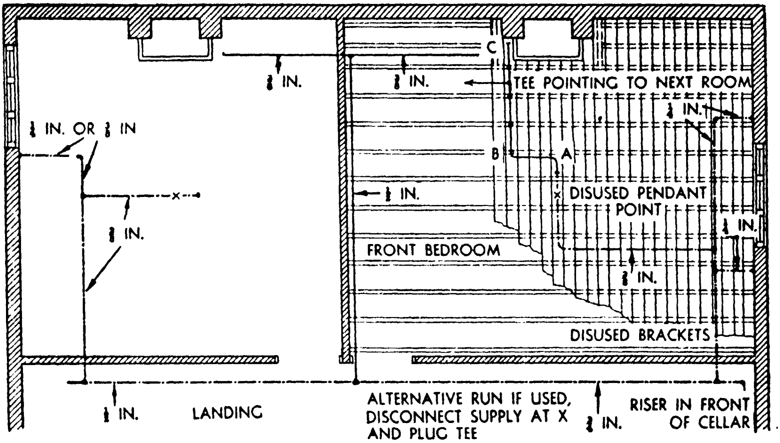


Fig. 16. Double fronted house. Rising main comes up from the front end of the cellar in $\frac{3}{4}$ in. and runs along the landing in $\frac{3}{4}$ in., reducing near the two bedroom doors to $\frac{1}{2}$ in. by means of a reducing socket.

material being $\frac{3}{8}$-in. barrel, it may be relied upon to give good practice. Fig. 3 shows a house carcassed upstairs for lighting only.

Start the run from the centre of the floor where there is a pendant lighting the room below, and if this pendant point has been correctly laid, it will appear as shown in Fig. 15 A. It will be noticed that the supply does not turn downwards by means of an elbow, but is supported by a short piece which extends through a chase cut in the next joist. Fig. 15 B shows the wrong method.

If electric lighting has been installed, the electrician will probably have removed the drop piece to which the gas pendant had been screwed, in order to pass his wiring through the same hole, or he may have removed the tee and short piece as well. All these possibilities are illustrated in Fig. 15 C, D and E.

A case might arise where the bracket points on each side of the first floor front windows are out of use, as well as the pendant below. In this instance it might be as well to search back until a socket is found, and begin the run from there, in this case proceeding along near the wall dividing this room from the middle room. Details of this method are shown in Fig. 16.

With an eye to further business, the go-ahead fitter will leave a plugged tee pointing towards the adjoining room. This is also illustrated in Fig. 16.

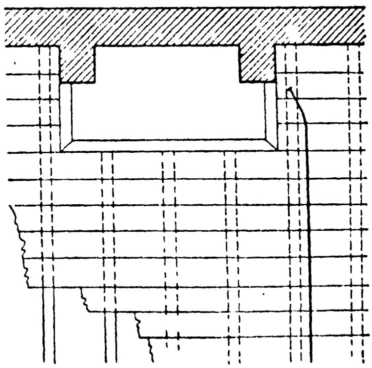


Fig. 17. Simple method of finishing fire supply with a set in the joist.

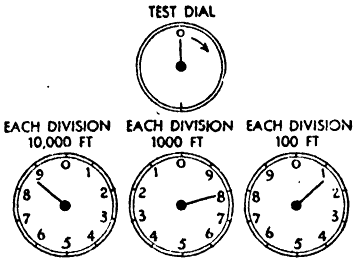


Fig. 18. Meter dials. The small test dial is employed when testing joints for leakage.

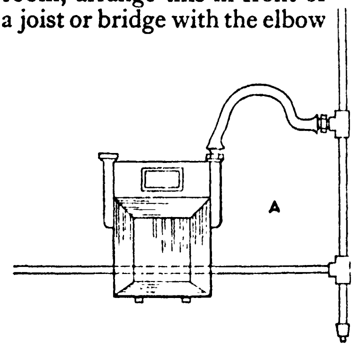
The procedure which should be adopted is as follows:

Turn off the gas at meter. Remove cap or plug and fit bend lightly. This will give a good indication of direction for the first half of the run. Measure the length of barrel required from A to B, and from B to C, C being the position for the fire tap. C should also be outside the hearth trimmer and about 3 in. away from it. If leaving a tee for the next room, arrange this in front of a joist or bridge with the elbow for the fire just behind. If the joists run the other way and the one next to the hearth comes close to the trimmer, the job can be finished off with a set in the joist itself as shown in Fig. 17.

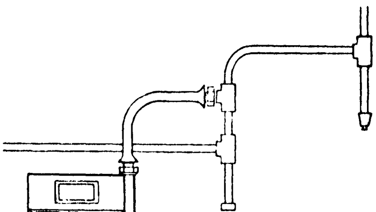
Now screw up the lengths of barrel between A and B, and mark off the joists ready for cutting the chases. After sawing, cut out the unwanted wood with a sharp chisel.

Fix the bend at B and screw in the length B to C. The pipe should now fit snugly into the chases. Unscrew pipes, paint male threads and tighten up again, beginning at the pendant point end, and proceeding joint by joint. Overtightening may split fittings. Drill a circular hole in the floor board by the fireplace and finish with a plug.

Now turn on the gas at the meter and note carefully the exact

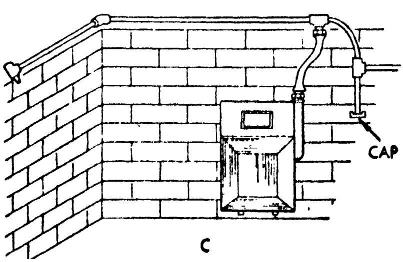


A

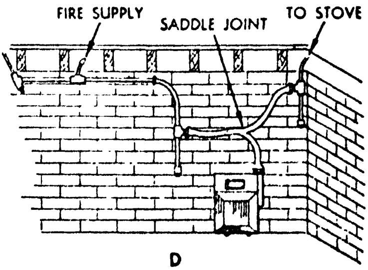


B

Fig. 19. A, B, C and D are varying methods of connecting metered supplies to the carcass. A and B are very common cases but D is typical of old property.



C



D

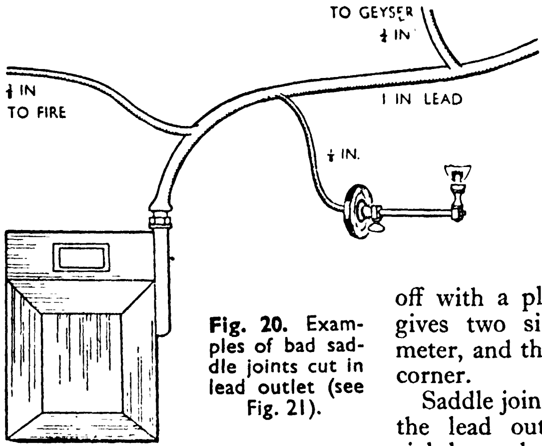


Fig. 20. Examples of bad saddle joints cut in lead outlet (see Fig. 21).

position of the pointer on the small test dial at the top, standing directly in front of the meter (Fig. 18). Make sure that no gas is being used elsewhere off this meter.

Sniff carefully around each joint, and if no smell can be detected, go over the joints carefully with a lighted match, blowing out afterwards. Leave the test on for at least a quarter of an hour, then look at the meter again. If the work is sound, the pointer will not have moved, and the flooring can be replaced. If the pointer has moved, there is an escape somewhere, and the joints must be made tight, then re-tested.

Fig. 19, A, B, C and D, shows varying methods of connecting metered supplies to the carcass. A and B illustrate two very common cases, the only difference being that in one case the riser runs directly off the meter lead and in the other a short distance away. The next is where the riser is on the opposite side of the cellar. This riser is finished off with a plugged tee. The last gives two siphons, one by the meter, and the other in the farther corner.

Saddle joints must not be cut in the lead outlet. They are unsightly, and often give way after prolonged use. Fig. 20 shows a bad example, but contrast this with the same job after a new lead had been fitted and all the existing supplies had been connected up in iron as shown in Fig. 21.

Fig. 19 D is typical of old property, but later methods for rising mains are shown in Fig. 19 A.

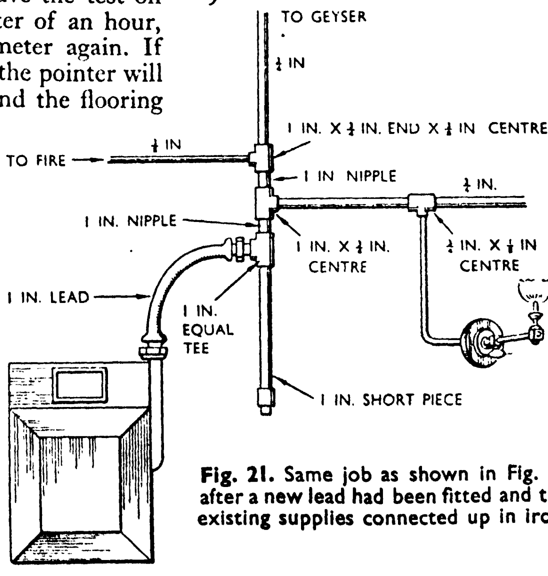


Fig. 21. Same job as shown in Fig. 20 after a new lead had been fitted and the existing supplies connected up in iron.

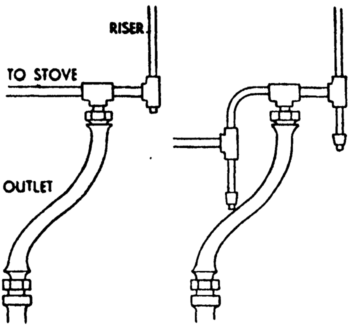


Fig. 22. (*Right*) Typical arrangement in small cellar or stair cupboard. (*Left*) Improved arrangement.

The main necessity in cooker supply is suitable running and this should be as straight as possible.

Begin at a fairly low level in relation to the meter outlet. If too high, the fitting of a siphon may prove difficult and result in condensation draining into the meter as in Fig. 22. Apart from this it does not matter much where the siphon is fixed as will be seen by reference to the illustrations of cellars.

The supply should be finished off with a stand pipe about a foot high, and capped. These supplies can often be pushed through directly from the cellar without having to remove many boards in the rooms they are supplying. If a small water-heater or copper is anticipated, plugged tees in readiness can be fitted, provided they will be required on the side of the cooker nearest to the cellar. If beyond the stove, the best method will probably be to fit a reducing tee near the end of the stove pipe, as in Fig. 23.

The principal and usual fault is that of bad supply. In turn this may involve the question of meter and pressure. Meters are dealt with later, but it will be readily understood that they are only worked by the passage of gas through their bellows, and a slight loss of pressure occurs.

Measurement of Pressure

Gas pressure is measured in 10ths of an inch against a column of water open to the atmosphere, and a gauge can easily be made by the handy man. Pressure is described as being 25/10ths, 30/10ths and so on. Occasionally it is referred to as $2\frac{1}{2}$ or 3 in.

A piece of $\frac{1}{2}$-in. glass tube should be carefully heated and bent in the middle into a broad based U. Mount this on a flat board slightly longer than the bent tube. Provide

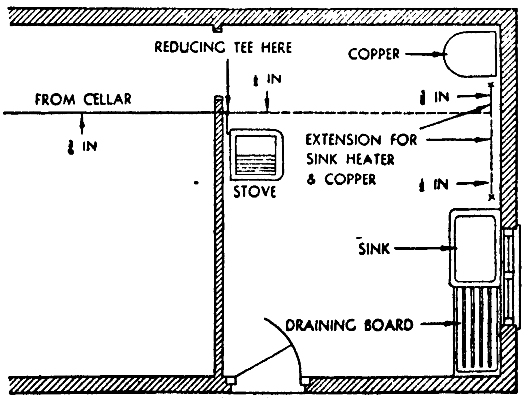
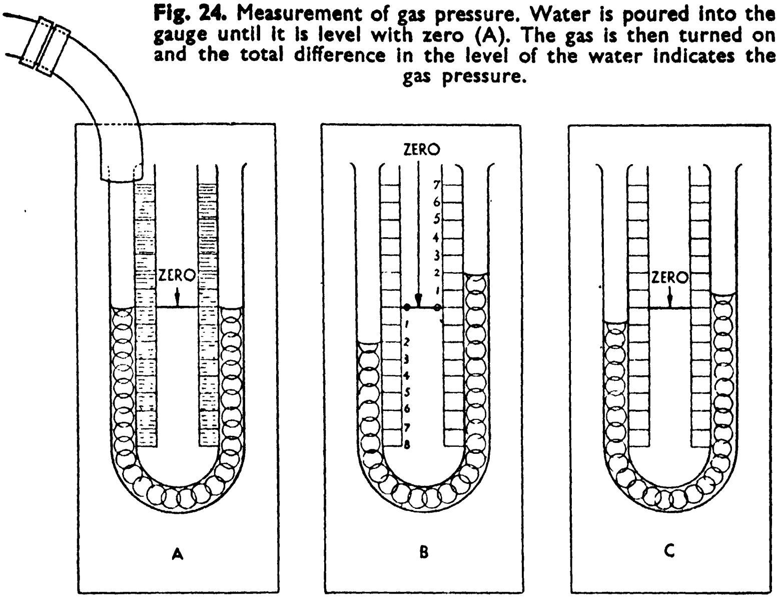


Fig. 23. Method of providing points in readiness for installation of small water-heater or copper. This arrangement is suitable when the tees are required on the side beyond the stove, farthest from the cellar.

Fig. 24. Measurement of gas pressure. Water is poured into the gauge until it is level with zero (A). The gas is then turned on and the total difference in the level of the water indicates the gas pressure.



a length of rubber tubing and slip it over one end of the glass, leaving the other arm open. Have a small clip on the rubber tubing, and at the end fit a brass nozzle with provision for attaching to different sizes of gas-supplies. Mark a zero line half-way down the tube, and further marks up and down in inches. This is clearly illustrated in Fig. 24 A.

Pour water into the gauge till it is exactly level with zero. Fix the free end of the rubber tubing to the gas pipe to be tested, leaving the clip on, or screwed down as the case may be. Gas should be turned off.

Now turn on the gas and gradually undo the clip. See that the gauge is level, and note the *difference* in the levels of water. The total difference shows the actual pressure in inches. Thus, if the gauge reads as in Fig. 24 B (2 in. each side) the pressure is 4 in., or correctly given, 40/10ths. If it is only $\frac{3}{4}$ in. as in Fig. 24 C the pressure of 15/10ths is too low, and suggests a stoppage somewhere. The pressure should not fall below 25/10ths.

If there is no direct evidence as to its locality, ascertain whether the bad pressure is general in the house, or confined to one or more appliances.

Assuming it is general, see that

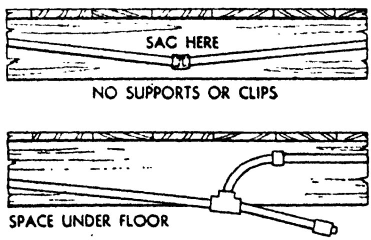


Fig. 25. Stoppage in fire supply. The pipe has sagged in the middle through inadequate support and is probably full of water at that point. Lower sketch shows the fitting of a siphon.

all siphons are emptied of water, especially any near the meter. This should remedy the fault. If it does not, anticipate trouble in the service and inform the gas company.

If only one or two appliances are at fault, disconnect them and test for pressure. As it is impossible to describe all eventualities, it will be assumed there is a stoppage in a fire supply. This may well be as shown in Fig. 25. The trouble is pretty obvious—the pipe has sagged in the middle through inadequate support and is probably full of water at that point. Sometimes fire supplies like this one can be seen from the cellar with the aid of a good torch.

To remedy the trouble it will be necessary to remove floor boards and clip up the pipe. Disconnection should also be made at the most convenient end, and the water drained out. If the pipe cannot be reset with a continuous one-way fall, a siphon will need to be fitted. It may have to go in the middle of the pipe, in which case it should be an extra long one, and the board replaced as a short screw-down trap.

Use of Force Pump

Stoppage clearance other than by drainage may necessitate the use of the force pump. This should be very carefully manipulated, as misuse may only aggravate the trouble by blowing the obstruction elsewhere. The particular pipe should be isolated if at all possible, and one end protected by a cloth or similar device to catch the dust or water. Should the pump be ineffective, relaying will be necessary, though this may not be so extensive as the word suggests. If the precise spot of bother can be found, cutting the pipe and inserting a connector will do just as well.

An almost certain indication of water in pipes is oscillation of gas pressure, due to the gas bubbling through the water.

The plugs in the control taps of brackets or pendants are liable to get blocked. If removed, make sure they are replaced the same way round. Cup and ball joints of pendants are a likely source of trouble, especially if particles of rust have fallen down into them.

On a large appliance such as a cooker trouble is often indicated by a yellow tip showing on the flame. Clearance of the burner nipple generally cures this, but do not use too large a tool for the job; a piece of thin wire is suitable.

Location of Leakage

The first principle to be adopted in the location of escapes is that of safety.

If the smell is unmistakable, open doors and windows, and shut off the meter. When all is fresh again, see that all interior taps are off and turn on again at the main. Watch the test dial. If it moves, the escape is on the house supplies. If not, but the smell reappears, the escape is on either the control cock, the inlet lead, the meter case or the service. Careful sniffing may locate it. In most cases this can be done on cock and meter, but possibly not on the service.

The best test for this is to pour along the service pipe a strong soapy solution, whereupon any escape of gas will bubble out like a leaky cycle tube. If the trouble is on any of these, inform the gas supply company at once. They should also be told if gas can be smelt inside the house but not

traced, as it may be percolating through the earth for some distance. A temporary repair can be made by wrapping the service with tallowed or waxed tape or cloth, or even by coating with ordinary softened household soap.

On no account attempt hot soldering on a meter, as there will be gas inside.

Escapes on outlet pipes may also be located by the soapy-water method in cases of long or horizontal runs. In the house escapes generally occur at joints, or on the plugs of taps. If the meter outlet lead has saddle joints, suspect these; they are a fruitful source of trouble.

The use of a light should only be resorted to when all other attempts have failed, and only then provided the escape is so small as to defy detection. Careful ventilation must always be given, especially under floors. Many cases have been known where a bye-pass has blown out, or the washer of a union given way. The rubber connections on flexible tubing perish, and in some cases the packing of similar tubing breaks down.

Repair of Small Escapes

Small escapes on joints can usually be repaired by the simple process of a coating of thickish paint. These escapes are sometimes caused by air bubbles being blown out after new work has been done, having collected in the threads of the joints. Splits in pipes and fittings are not unknown, and may cause serious escapes. If the section is very short, a short or two and a connector will put things in order again.

In spite of the publicity given to accidents caused by defective or non-existent flues, examples are still to be found where these most necessary fitments are found to be entirely lacking.

Small first-floor rooms are often ventilated with an air-brick opening outside just under the eaves. Do not use these gratings to ventilate gas fires. Apart from their probable inefficiency, there may be by-laws preventing such use.

Common sense should decide on the type of appliance to fit in a flue-less room, but in the case of portable gas heaters, the limit of consumption of 1 cub. ft. per hour per 100 cub. ft. of room dimension is a good general rule.

Radiants

Radiants, or fuel as they are commonly called, are made of light refractory material, and their function is to store and transmit the heat offered by the flame.

Their design is very largely bound up with the fire to which they belong, and care should therefore be taken to see that the correct radiant goes into the fire which is under repair.

To complete this gas section, a few notes about meters will be useful.

Gas was first sold only for lighting, and the standard burner used about 6 ft. of gas per hour. The average small house had five burners, and used, therefore, 30 ft. of gas per hour, if all were in use together. The meter for this became known as a five-light meter, and this method of dividing the total rated consumption by six gave the required size of meter for many years. Modern methods and often limited space developed the high-capacity meter of today, and the "lights" meter has in consequence declined in its favour.

ELECTRICITY

ELECTRICAL TERMS. CONDUCTORS AND INSULATORS. FORMS OF ENERGY. FUSES: CONSTRUCTION AND PURPOSE. WIRING SYSTEMS. SAFETY RULES. CONDUIT CONNECTIONS. JOINTING WIRES. CABLE AND FLEX. METHODS OF WIRING. ADDITIONAL SWITCHES. TRACING FAULTS. AUTOMATIC CONTROL.

ELECTRICITY is a good servant but a bad master. Unlike gas, which warns us by its characteristic smell, electricity offers only physical shock, and, when leaking, acts so rapidly that untoward results frequently occur.

Properly installed and intelligently used, however, this mysterious commodity, for mysterious it still is, is of the utmost service to all.

It is, therefore, of the greatest importance that every action involving alterations or additions to wiring should be carried out in an atmosphere of safety first, and this recommendation cannot be too strongly stressed.

Like gas, electricity has pressure, and a severe pressure drop will cause trouble, but in normal conditions of supply this is not likely to happen. For many reasons, both domestic and technical, the supply companies pay a great deal of attention to keeping their declared voltage constant. Any variation which may occur is not likely to be more than a very low percentage.

There are limits, however, to the amount that should be put on circuit, in spite of the opposite impression which appears to be widespread. There is also a correct size of wire for every job, though a complete list of these would be bewildering here. Only the best quality wire should be used and every care should be taken to ensure that it is heavy enough for the duty it is to perform and that the circuit does not become overloaded. The Institution of Electrical Engineers provides a schedule of wiring sizes with the maximum amperage they are designed to carry.

The learner has but to look at specimen wiring diagrams to realise the ramifications and intricacies of this science. It is therefore with a feeling only of confidence and knowledge of the subject that he should embark on the fitting of new electric supply points. This warning, however, need not deter him from tackling even complete installations as well as obvious repairs.

Electrical Terms

Before proceeding to work, it is necessary to understand some of the terms used in electrical supply.

First there are the four essentials relative to actual use—volts, amperes, ohms and watts. These may in turn be briefly described as pressure, flow of current, resistance offered by the conductor, and quantity used.

Voltage is the pressure or force with which the electricity is conveyed along the conductor. It is also known as electromotive force.

An *ampere* has been defined as the current given by one volt through a resistance of one ohm. It corresponds to the current flowing through the wire at the time. If the voltage is doubled but

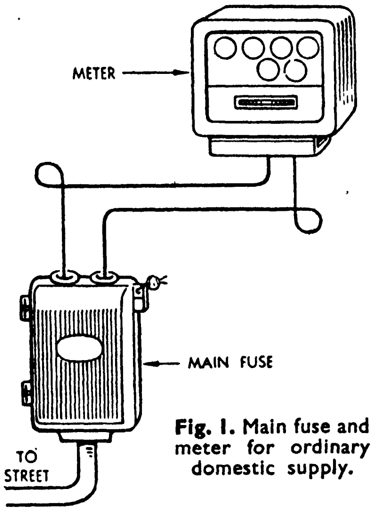


Fig. 1. Main fuse and meter for ordinary domestic supply.

the resistance retained then the amperes flowing are doubled. From this the following is deduced:—

$$\text{Amperes} = \frac{\text{Voltage}}{\text{Ohms}}$$

$$\text{Volts} = \text{Amperes} \times \text{Ohms}$$

$$\text{Ohms} = \frac{\text{Voltage}}{\text{Amperes}}$$

Wattage is calculated by multiplying voltage by amperage. All these terms except ohms are abbreviated, as follows: Voltage... volts; Amperes... amps: Wattage... watts.

Ohms.—An understanding of the term Ohm is perhaps best based on the assertion that the flow of electricity does not proceed without hindrance. The wire sets up a resistance to the flow, just as a roadway does to a stream of water.

This *resistance* plays a most important part in the industry, as the functioning of most appliances is based on it. By mounting suitable wiring which becomes heated because of its resistance to the flow, the necessary warmth is assured, and this is the basis of nearly all electrical heating and lighting, the latter because the necessary incandescence of the filament is brought about by heat.

A *watt* is the basis of charge and is also a measure of quantity used. It is of itself too small to be charged, and recourse has been made to a more convenient standard of 1000 watts, called a Kilowatt, or KW. This is really the use of 1000 watts over a period of one hour, and is more correctly termed a Kilowatt-hour, or KWH. It is often called a Unit, and many electricity accounts are charged as so many Units.

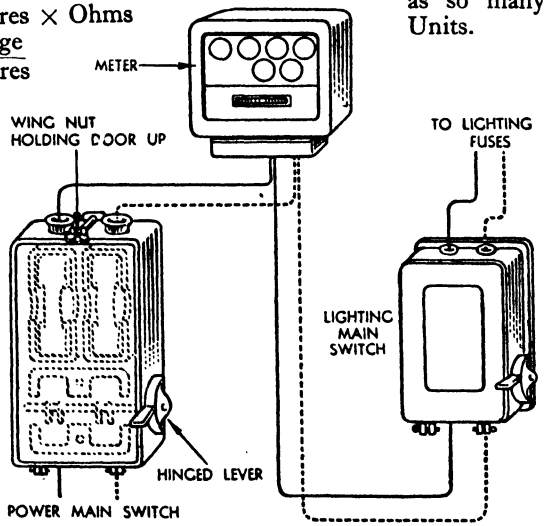


Fig. 2. Modern domestic installation. In this case there are two main switches, as the power is a separate circuit.

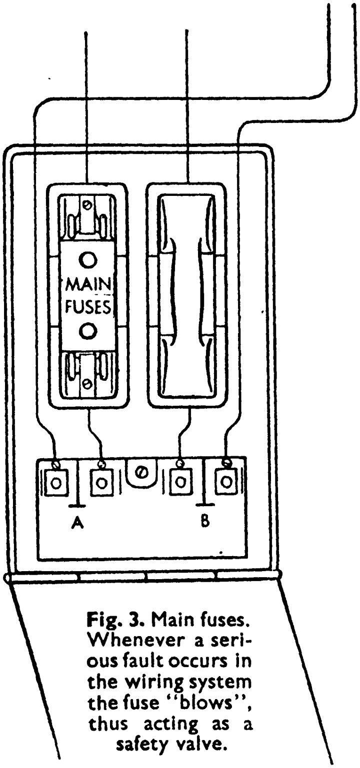


Fig. 3. Main fuses. Whenever a serious fault occurs in the wiring system the fuse "blows", thus acting as a safety valve.

From the mains, heavy cables are taken into properties and fitted with fuses to control the safety of the supply and to guard against excessive voltage being passed. These main fuses are then connected to the meter from whence run the house supplies (Fig. 1).

The house main switch controls the whole of the installation. This is double-pole—that is, bridging both positive and negative cables. If there is a separate power circuit, then there is a separate power main switch as shown in Fig. 2. Following the switches come the fuses, which, like the main fuses, act as safety

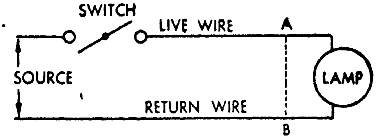


Fig. 4. Simple arrangement of electrical circuit showing out and home run. A–B shows possible short circuit.

valves, and break, or "blow", whenever a serious fault occurs in the house wiring (Fig. 3).

In modern installations these fuses are fitted in the same control box as the switch, and to ensure safety, the box cannot be opened to remove the fuses until the main switch is off. This introduces the first general rule—in all cases switch off at the main before removing fuses.

After the switches come the distribution boards, from which are run the various circuits. In small installations these are generally called fuse-boxes.

Electricity always returns to its source or to earth and always takes the line of least resistance. Any complete out and home run is called a circuit. If a fault causes a current to take a shorter route, as A to B, then it is known as a short circuit (Fig. 4).

Some bodies offer very little resistance to the passage of electricity, and these are called *conductors*. Other materials will not

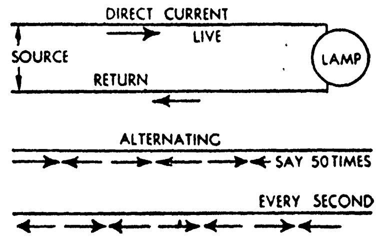


Fig. 5. Two forms of electrical energy: direct and alternating current.

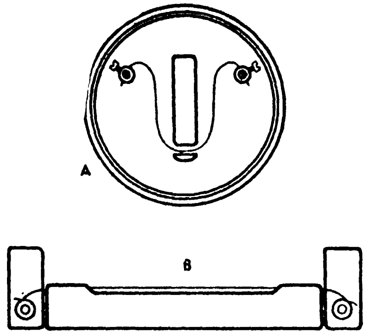


Fig. 6. Fuses will carry only a specified amperage and if a greater current passes through or short circuit occurs the wires melt and the supply is thus automatically cut off.

carry current, and these are *insulators.*

The best conductor is silver, closely followed by copper, then gold and aluminium. Metals in general are good conductors and so also are carbon and water. That the human body is an excellent conductor is obvious, as the number of fatalities from electric shock have proved.

Copper is the most widely used conductor, owing to its ease of manufacture, relative cheapness, softness and capacity for taking alloy.

Insulators in common use are Vulcanised India Rubber (V. I. R.) porcelain, Bakelite, glass, mica, paper, silk, cotton, shellac and paraffin wax.

There are two forms of electrical energy supplied, *direct* and *alternating*. Both systems are in use in public service. Most places now have alternating, or A.C., as it is called. This form actually flows back and forth between the generator and appliance so many times per second, called cycles. To simplify description, a 50-cycle service for 250 volts alternating would be described as "250 v. A.C. 50 cycles". Cycles is also written ~. Alternating supply has a return wire, or neutral, the same as direct current, which flows in one direction only, completing the circuit, as shown in Fig. 5.

Fuses are the safety-valves of electric supply. They consist of thin wire, usually tin-lead alloy, of a low melting point, and are made for current of definite amperage, generally 5, 10, 15 or 20. They are strong enough to bear the voltage of the specified house supply, but if a much greater current passes through,

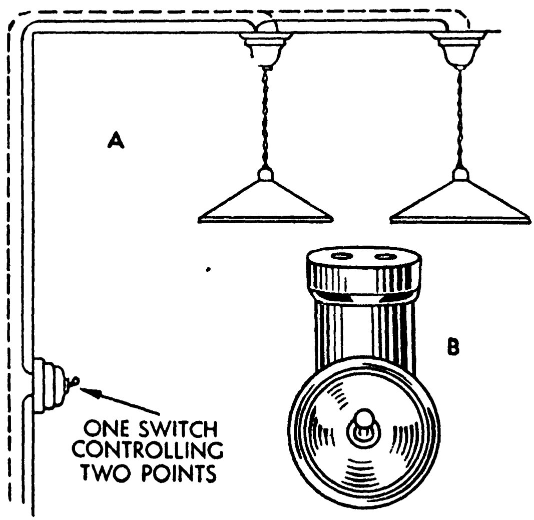


Fig. 7. In this case two lights are controlled by one switch, and switched on or off simultaneously.

these wires melt, or fuse as it is called, and cut off that particular part of the system. This is illustrated in Fig. 6 A and B.

Switches are a means of controlling the use of circuits by breaking the continuity of the wiring. Fig. 7 A shows how a switch may control one or more lights according to circumstances or need. Two switches may also control one light.

Where live plugs are fixed, switches should also be provided to control the plug, and if the plug is for heavy duty, the switch should be adjacent, preferably incorporated as shown in Fig. 7 B.

Individual types of both switches and plugs are far too numerous for all to be either described or illustrated, but one or two examples will appear later.

Methods of Wiring

There are several methods of wiring in common use, the simplest being the Cleat system, which is the mounting of V.I.R. cable on porcelain cleats fixed at intervals along walls or ceilings. This system must only be used where the cabling is visible, and not at all under floors or in damp situations.

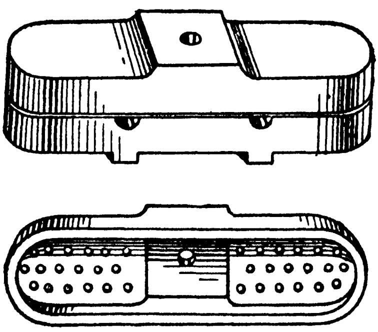


Fig. 8. (*Top*) Closed cleat; (*bottom*) top section of open cleat.

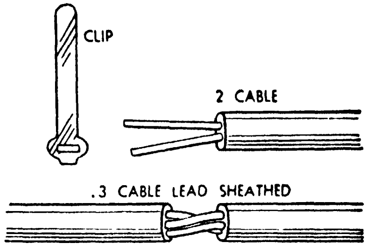


Fig. 9. Wiring by means of twin or triple V.I.R. cables encased in a lead sheath. Fixing clip is also shown.

A suitable job would be where cheapness and simplicity are of the utmost importance, such as a temporary stores; a job which is described later and illustrated in Fig. 13.

Another system is the Conduit, in which cables are drawn through metal tubing which is laid for the purpose.

Conduit tubing has several types of jointing. Screwed tubing hardly needs explaining, and with grip fittings set screws are used. Numerous junction boxes and fittings are made for use with conduits, which must be both mechanically and electrically continuous, and earthed.

A later development of wiring is by means of twin or triple V.I.R. cables encased in a lead sheath. It is very easy to install, the only extra care needed in its use being to avoid twists which might result in splitting the sheath. This is shown in Fig. 9.

Similar in use and still less conspicuous is the Cab Tyre Sheathed cable. This is V.I.R. cable heavily protected by tough rubber.

For use with conduit, special junction boxes and tees, are provided. These facilitate the drawing through of wires, and some are made with detachable

covers so that the cabling can be inspected at any time. One particularly good feature is the provision of a box where a switch is to be fixed, where the conduit is chased in the plaster or brickwork. The box is also recessed, and is placed so that it coincides exactly with the switch position, which is screwed to it, the drilled lugs on the box being placed at the same distance apart as the standard switch measurements.

For angles such as occur at ceiling level for changes of direction, boxes of rectangular design are also available, as in Fig. 10.

Conduit is clipped to woodwork by means of saddles (Fig. 11), and to plaster by pipe hooks. If there is any trouble about the security of the fixing, one of the well-known types of wall plug will usually solve the problem, but nails should not be used.

Screwed conduit is threaded with a special thread called electric thread, to distinguish it from the standard gas thread, which is larger. Gas thread should not be cut on conduit, as the tubing is not stout enough for the purpose, besides which the fittings are threaded internally to the correct size.

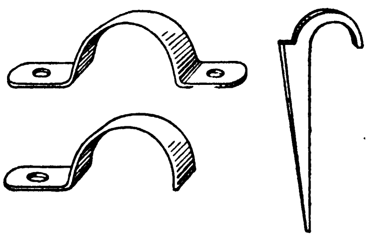


Fig. 11. Types of saddle which are employed for clipping conduit to woodwork and pipe hook for attaching to walls or plaster.

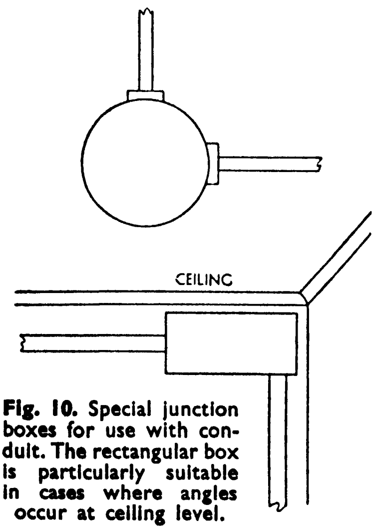


Fig. 10. Special junction boxes for use with conduit. The rectangular box is particularly suitable in cases where angles occur at ceiling level.

If changes of direction are necessary and fittings or boxes not desired, the conduit should not be bent more than is necessary, as sharp turns make it very difficult to draw the wiring through, but if unavoidable a larger size of conduit might be advantageously employed.

If it becomes necessary to join two lengths of cable where the conduit system is used, the junction must be made at the nearest convenient box, and one of the small porcelain or rubber-protected sleeved connectors used inside the box.

Earthing conduits are described at the end of this chapter.

Rules on Procedure

The following are a few rules which should be observed before commencing a job:

1. Don't replace fuse wire with the switch on. Switch off first.
2. Don't do any electrical connecting unless certain that the main switch is off.

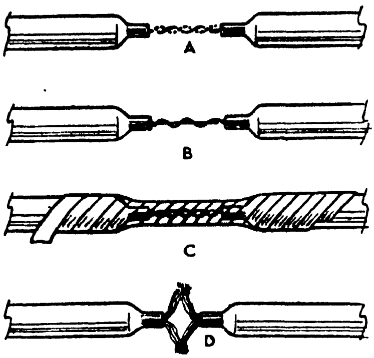


Fig. 12. Method of jointing cable and flex.

3. Don't fix metal cover switches in bathrooms, or where stone floors are laid, or near gas or water taps, and don't have electric fires in bathrooms.

4. Don't fit any heavy duty appliance such as a fire or copper to a lighting point. They require much heavier fuses and wiring, with which the power circuit is provided.

5. Don't bare too much wire when making joints. On the other hand, don't skimp—you can't stretch it.

6. For sunk switches leave long ends, the surplus of which can be tucked in around the recess.

7. Don't fit cheap foreign lamps thinking to save money. Their actual consumption of current often exceeds their rated wattage by a considerable percentage.

8. When wiring begin at the farther end and finish at the fuse-box.

9. Always see that the switch is connected to the live main, and use the negative wire to connect source and lamp.

10. Don't overtax the circuits. There are limits laid down.

11. See that all lamps and appliances are correctly rated for the local supply. If made for a lower voltage they will soon burn out.

12. Don't forget "Safety First" always.

Jointing Wires

As all the jobs herein specified, both new and repair, will include preparation and jointing of wires, it will be well to detail here the method used for the latter, together with the tools likely to be required for the various tasks, and also to touch upon the choice of suitable gauge wiring.

For tools there should be a light hammer, flat-nosed pliers with wire-cutter, and small half-round nose pliers; one or two screwdrivers, one having a long thin blade and an insulated handle, a chisel-edged bradawl for the tiny wire-gripping screws in switch terminals; a roll or two of insulated tape, say ½ in. and ¾ in.; fine sandpaper. A small pair of sharp-pointed scissors and an ordinary gas pliers will also be found very handy tools. Fuse wire is sold ready mounted on cards.

To decide upon the size of wiring for any particular job the first consideration is the finding of the amperage. This will be the known voltage of the supply divided into the total wattage of the proposed load. For instance, if wiring for an additional load of 6 lamps each of 100 watts on a 200-volt supply, then the current load would be 3 amps. As it is usual to provide for a safety factor of about 100 per cent at least 5-amp. wire should be used.

The general term wiring is sectioned into *cable* and *flex*, each

of which is differently constructed from the other.

Cable consists of one or more strands of copper wire, tinned, covered with two or three layers of rubber sheathing, then taped and braided. Flex has numerous strands of very fine gauge wire, wrapped in cotton strand, then rubber and finished with cotton or silk braid. V.I.R. is cable with additional rubber covering.

Jointing Cable

Cut away the covering on each length for about ¾ in., and clean the wire with sandpaper. Pare away additional outer insulation for another half inch or so. Twist the wires together with the flat-nosed pliers, being careful to twist each wire, and not merely one around the other as in Fig. 12 A and B. Wrap rubber strip well round the joint, and if possible solder the joint first. Finish off with insulating tape, starting well back from one end on the outer covering and proceeding like a puttee to a similar position on the other cable as illustrated in Fig. 12 C. This should result in a strong firm joint.

For flex the procedure is similar, except that the strands of the wires should be parted and several at a time twisted up with those on the corresponding opposite flex. If the centres in each case are brought closely together, allowance can be made for bending back any surplus wire, making the joint still more secure (Fig. 12 D).

Much better joints can be made by the use of junction boxes. These are of various kinds, for single, double and triple wire. Brass sleeves fitted with screwed terminals are enclosed within porcelain covers. Others consist simply of conical porcelain caps with a threaded inside, into which two or more wires are inserted and twisted.

If an existing flex length serving a standard lamp or similar appliance is found to be defective, possibly through friction, it should be replaced by an entirely new length, and not repaired by a join. The only exception to a new length is when the fault occurs at one end, in which case the wire can be shortened.

Two or three typical jobs will now be described, each using a different system of wiring. Some knowledge on the part of the fitter is assumed, for instance the ability to fix a lampholder without detailed instructions, this being within the capability of almost any householder who uses electricity for lighting. In the first example the Cleat system is employed and the structure is the temporary stores referred to in Fig. 13.

(1) Assume an office building, the ground floor back room of which leads out to a yard in which it is proposed to erect a temporary lean-to shed to serve as a stores. Lighting will be required to two lamps centrally fitted, but they need not have separate switches, as although the place is small, ample light is required evenly distributed. Owing to the temporary nature of the structure, the first consideration is rapidity and economy in installing the lights.

Looping-in

As the main fuses and meter are in the front of the main building some 20 yds. away the simplest method is to run from the existing lighting point in the back room. This is called the looping-in method, although the procedure

as an addition would be slightly different from that in which the lights in question were run as one job.

The switch controlling the light in the back office will most likely be a surface fixed one, with the wiring coming downwards through the plaster and in at the back. It will probably be fitted on a wooden block. As the new wiring will be surface work, it will be necessary to detach this block and cut a groove in it to accommodate the new wire, and a hole through the back for the same purpose. The main building is wired in V.I.R. run in conduit, so the same material will be used minus the conduit.

Procedure

First of all it is necessary to make sure the existing installation is not at the limit of load for this floor. Examination will probably show that the fuse is 5 amp., and the maximum load for this is ten lamps, according to I.E.E. regulations. This fuse controls the whole of the ground floor, on which there are only four lights, three in the front office and one in the back. Two extra lights may therefore be added.

Switch off at the main. If the lighting is required in the upstairs offices, remove the fuses for the ground floor and switch on again. This will cut out the lower floor, allowing work to proceed, while leaving the top part of the building in lighting.

Measure up for the wiring. The new live lead (red) will run from the live side of the existing switch in the back office to one terminal of the new switch. From the other terminal run more red cable to one connection on the first ceiling rose, and continue with the same cable to one terminal on the second rose. This completes the red. From the other terminal of the second rose return via the unused connection on the first rose to the dead wire in the back-room ceiling rose (Fig. 13).

In actual practice the job may be done the other way round—that is, a start may be made from the second rose. The reason for this is that before the final connection can be made the live side of the original switch has to be identified, also the dead or neutral wire in the original rose. As this latter was the end light in the house installation, there will likely be one wire in each of the rose terminals, and one should be black, whether the other is red, orange or white.

This black wire is probably the

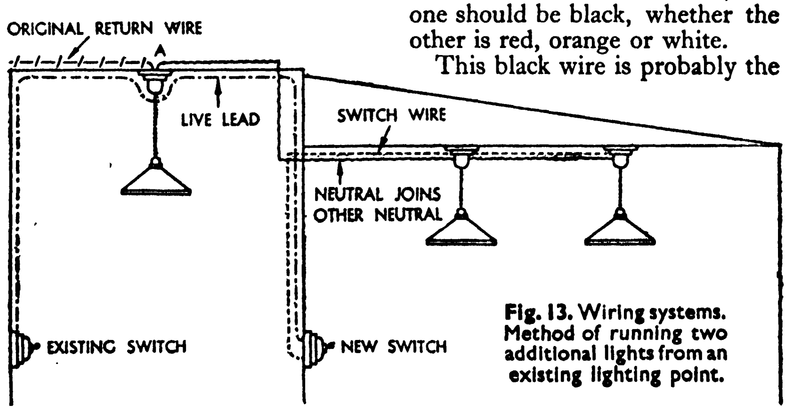


Fig. 13. Wiring systems. Method of running two additional lights from an existing lighting point.

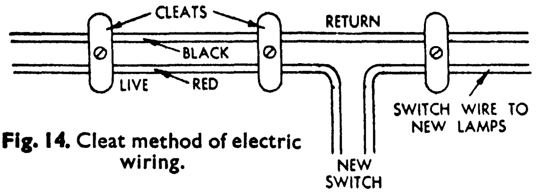


Fig. 14. Cleat method of electric wiring.

dead one to which must be attached the black cable from the new roses. Now bare the loose end of the red cable and have it ready for the test. Complete the flex to the lamp-holders, and fit lamps. Switch on at the main, having first of all detached the original switch but not removed any wires. Hold the bared end of the loose cable to one of the back-room switch connections, taking care to handle it only by the full insulation, and see if the lamps light. If they do not, the switch wire has been connected (the one between switch and original rose). The other one must be the live wire, and this should light up the lamps. The connection may now be properly made and the switch re-fixed.

Fixing the Cleats

Cleats are made of porcelain, in two portions. The upper part is roughened on the under side rather like the outer sole of an overshoe, so as to grip the V.I.R. cables which lie in grooves cut across the lower half of the cleat. For twin wiring a single-hole cleat is provided for screwing directly to walls, but, as in Fig. 8, larger ones are available when four or more wires are required, and these, of course, have a greater number of screw holes.

Cleats should be fitted about 2 ft. apart, and if run horizontally should be as high as possible, or at any rate out of reach (Fig. 14). They must be drawn tight. The result of the stores job is shown in part in Fig. 14, where the return cable passes the switch leads.

(2) The owner of a small suburban house with a large front garden desired to have a lantern fitted outside. Twin lead-sheathed cable was used, with current taken direct from the fuse-board.

Connections to existing fuse-boards were made by fitting the live wire to the top terminal of a pair of fuses, and the return wire to the other terminal. If the fuses are side by side, the left-hand one is the live side. In this case they were top and bottom.

The fuse-board is at the back of the cupboard under the staircase (Fig. 16), and the switch is fitted to the woodwork near the door in front, almost opposite the dining-room. This position was selected because the light could be switched on and off without having to grope down the hall to the front door, by the side of which most switches of this kind seem to be fitted. The light afforded sufficient illumination inside the hall for the return walk to the switch.

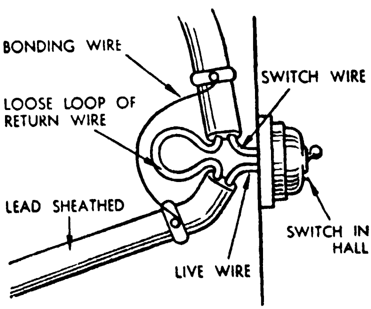


Fig. 15. Bonding wire in a job where the lead sheathing has been broken.

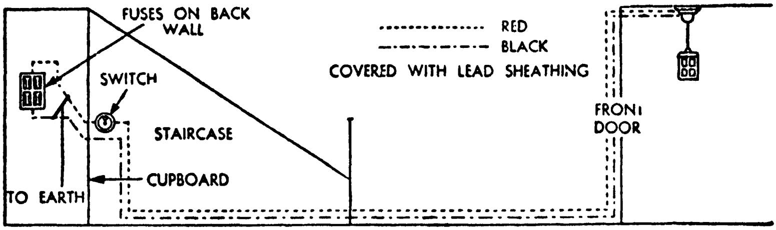


Fig. 16. How wiring was run from the fuse board for a garden lantern which was fitted outside the front door. The cable is conveniently earthed as shown.

The switch was fitted to the woodwork, the cable coming across the cupboard for the purpose, attached to the nearest stair. To avoid the necessity of making a joint, only the red wire was severed, sufficient sheathing being cut away for this purpose, while the unrequired length of black was looped up. This cutting of the sheath broke the continuity of the metal earth, and this was restored by a short bridge of wire clipped to the lead sheath (Fig. 15).

The cable was then passed down through the stair cupboard and along the top of the skirting behind the hall-stand, up the corner and through the window-frame. From this point to the ceiling rose the cable was covered with wooden casing.

The main earthing wire was long enough to be looped over the screw of a clip fixed near the fuse-box (Fig. 16).

Automatic Control

At the same time the opportunity was taken to fit a switch on the cupboard door controlling a light inside the cupboard. This comes on automatically whenever the door is opened, and goes off again when the door is closed. A special switch was purchased for the job, and the only trouble in fitting it was to get it in just the right place. This is illustrated in Fig. 17.

(3) Fitting an extra switch for an existing light is a simple and inexpensive job. Two two-way switches will be required, and the present switch discarded, so far as this job is concerned. A length of triple-sheathed wiring, which is long enough to reach from one switch to the other, will also be required.

First switch off at the main, then disconnect the existing switch. If the live terminal contains two wires, leave them together. Two of the terminals on each new switch will be separated from each other, whilst the other two are connected by a bridge piece. Connect the disconnected wires from the old switch to each of the separated terminals of the new

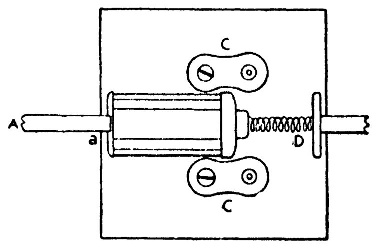


Fig. 17. Automatic light control. When door is shut A is pushed along to *a* and the contacts CC are cut off from each other. When door is opened the spring D pushes the plunger down again, thus closing the switch.

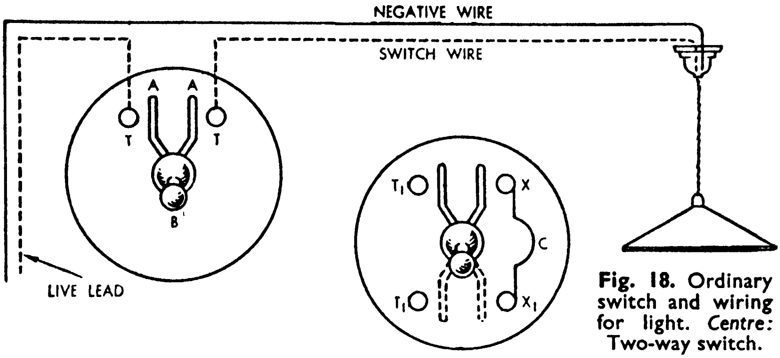


Fig. 18. Ordinary switch and wiring for light. *Centre:* Two-way switch.

switch, and one new lead to each, whilst the third wire of the new lead must be fitted to the bridged terminal. Now run new wiring to the other switch and fit last wire to the bridged socket with the other two to the two separated points. Details are shown in Figs. 18 and 19.

One of the commonest of faults is the failure of one lamp. If this is the only fault, all the other lamps on the circuit should remain alight when the switches are closed. If any other lamp does not light, look for a blown fuse.

If the fuse is in order, examine the flex between ceiling rose and lampholder, or in the lampholder itself. One strand may be broken.

The switch may be faulty. This will be apparent, as a rule, if both fuse is intact and the lamp lights when tested in another circuit. Perhaps the contacts have become bad, or the coil springs weak. If it is spring trouble, the best remedy is a new switch; but bad contacts may often be cured with a screwdriver, using a little pressure.

If replacing a switch, be very careful that two wires looped into the same terminal are not separated when drawn from that terminal, also that they both appear in the new switch together. The second one is almost sure to be a live lead to the next switch.

If a fuse burns out repeatedly, the trouble will be a short circuit. This trouble must be located and rectified before the fuse is replaced again. If junction boxes are fitted, examine for faulty joints in elbows and tees. Connections may be "shorting" across to a neighbouring wire.

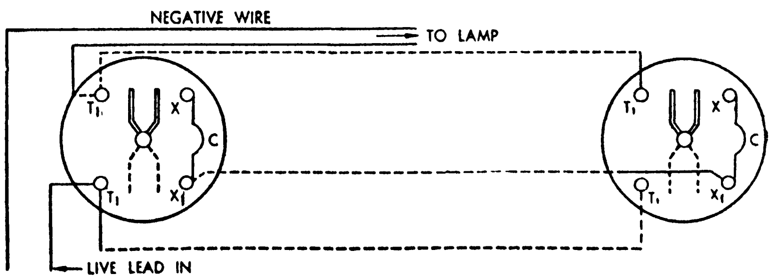


Fig. 19. Extra wiring with two two-way switches, each of which will control the one light which is illustrated in Fig. 18 above.

CHAPTER 10

PAINTING AND DECORATING

COMPOSITION OF PAINTS. BASIC PIGMENTS. MEDIUMS AND THINNERS. READY-MIXED PAINTS. SPREADING CAPACITY. CARE OF TOOLS. TREATMENT OF BRUSHES. PRINCIPLES OF PAINTING. EXTERIOR AND INTERIOR PAINTING. PREPARATION OF SURFACES. KNOTTING AND PRIMING. UNDERCOATS AND FINISHES. DISTEMPER. PAPERHANGING. COMMON ADHESIVES. MEASURING UP. SHADING AND TRIMMING. FRENCH POLISHING.

IN painters' work, success will largely depend on a proper understanding of the characteristics and reactions of the surfaces to be treated, the peculiarities of particular paints and varnishes used and, finally, upon the ability and experience of the craftsman. This being the case, it is advisable to consider both the advantages and the limitations of various materials in order to avoid or minimise the numerous defects which attend their indiscriminate use.

Composition of Paint

Oil paint is composed of pigment or inert base, a medium or binding agent, a drier, and a thinner. Distempers and water paints also contain these ingredients, with the exception of driers. Both pigment and medium are of paramount importance in deciding the subsequent behaviour of a paint. Under outdoor conditions the best white lead would fail, unless combined with a protective medium of equally good quality.

White carbonate of lead has long been recognised as the best white base for paints exposed to humid conditions. It is equally valuable at all stages from priming to finishing coats, and for the latter purpose may be tinted. Its disadvantage lies in the fact that apart from its poisonous nature, it is discoloured by sulphurous fumes, and is, therefore, unsuitable for flat finishes.

Zinc oxide is non-poisonous, unaffected by fumes, and when combined with white lead in the proportion of one of zinc to five of lead, a really good outside paint is produced. These leaded-zinc paints are extremely durable, and retain their whiteness for a longer period than white lead alone.

Lithopone is a non-poisonous zinc compound with a high degree of opacity (hiding power), and superior spreading capacity. It is moderate in price, and is probably the most widely used basic white for interior work, particularly for undercoating and bodying up. It has, however, no weather-resisting properties.

Mediums such as linseed oil, oil varnishes, cellulose and other synthetic products, serve not only as binding or fixing agents to the pigment, but supply the gloss,

weather-resisting properties, and any elasticity the paint may possess. Water mediums, even oil emulsions, are completely devoid of gloss and elasticity, consequently they cannot be regarded as being efficient preservatives for wood or ironwork.

Linseed Oils

The easy brushing properties, paleness of colour, drying qualities and toughness of the film when dry, combine to make *refined linseed oil* the most widely used paint medium. The drying action is quite unusual in character, there being no evaporation, but, on the contrary, there is an active absorption of oxygen from the air, which results in a chemical as well as a physical change.

This action is accelerated by the admixture of lead pigments, and to a much greater extent by the addition of driers (certain metallic oxides), but if too much drier is added, the paint film speedily loses its elasticity and gloss, with the result that its life is considerably shortened.

Two varieties of *boiled linseed oil* are available. One is the old type which is dark in colour, and the other a pale boiled oil for use with more delicate colours. During the cooking process, oxides of lead, manganese or other drying agents are dissolved in the oil to improve its natural drying properties: partial polymerisation (thickening) of the oil also takes place, and gloss is thereby improved.

Refined oil is generally employed in undercoats, and the boiled oil in finishing coats upon less important outside work.

Oil varnishes are simply cooked oils, containing varying proportions of resin, driers and thinners such as turpentine or white spirit. "Elastic" or "outside-quality" varnishes contain a higher proportion of oil and are more durable than the hard varnishes employed for interior work.

Oil varnish is frequently employed to impart a better and more lasting gloss to oil paint, but experience shows that some varnishes do not mix satisfactorily with linseed oil, hence the advisability of using one of the specially prepared *mixing varnishes.*

Solvents or Thinners

Turpentine, white spirit and naphthaline, by their solvent action upon the oil medium, thin the consistency of a paint, reduce gloss, produce a harder paint film, increase the spreading capacity and ensure easier application. The paint dries more rapidly because the solvent evaporates completely within an hour of application, leaving the medium behind to dry by oxidation.

In flat paints the proportion of thinner to medium may be six to one, and vice versa in the case of gloss finishes: while for semi-gloss paints, proportions may be equal. Genuine turpentine is undoubtedly the best and safest thinner.

Oil Troubles

White spirit and shale spirit are, if carefully manufactured, exceedingly good substitutes, but any carelessness in their preparation may result in failure to eliminate completely the greasy, non-drying mineral oil from which the spirits are distilled. Mineral oil causes such troubles as "cissing", delayed or "imperfect drying" and "sweating" of microscopic globules of oil.

Naphthaline has valuable anti-

fungoid properties, and is frequently employed in priming paints for use upon woodwork. Its powerful solvent action renders it unsuitable for use in later coatings.

Ready-Mixed Paints

Although mixed from ordinary pigments, ready-mixed paints often contain mediums, and sometimes thinners, widely different from those already enumerated. How these differences in composition affect the character, use and method of application may now be briefly summarised.

Synthetic high gloss paints and enamels contain as binding agent an artificial resin fused with a drying oil (linseed, or tung oil), thinned with a suitable solvent. One should ascertain, before making a purchase, whether the paint in question can be safely used upon an undercoat of the ordinary type; if not, it may be assumed that the solvent employed is too powerful for use except upon a special undercoat supplied by the manufacturer.

Many synthetic finishes give every satisfaction upon surfaces prepared with lead paints. They are particularly resistant to the action of weather and to alkalies; their drying speed ranges between four and eight hours.

Enamel Paints

In gloss finishes, toughness, durability and gloss are of greater importance than opacity. It is therefore usual to employ the minimum amount of pigment with a larger proportion of medium than would be necessary or desirable in ordinary oil paints.

Stand oil or lithographer's varnish, obtained by cooking linseed oil until a syrup-like consistency is reached, is a common ingredient. As in the case of "blown oil", this may be further improved by passing hot air through the cooking oil until some degree of oxidation occurs. Oils of this type possess better body, drying properties and elasticity than linseed oil. The properties of hardness, so desirable for interior work, and increased toughness for exterior work, are imparted by the admixture of suitable resins.

Rubberised Paints

Rubber has for some time been incorporated in certain proprietary paints, with excellent results. It can, according to the process employed, be mixed with oils or resins, or both, to form either a glossy, elastic finish, or an unsaponifiable (undamaged by alkalies) priming coat for Portland cement and other alkaline surfaces which have previously been the cause of paint failures.

Bituminous paints vary considerably in quality, colour and price. The cheaper forms, such as Brunswick and other heat-resisting blacks, are useful in their proper sphere, which is indoors. For exterior work there is a wide range of highly durable, anticorrosive paints which are frequently used upon cement stucco and ironwork, particularly rainwater goods. The shades available are usually dark tones of green, grey, brown or blue, although there is at least one well-known brand of white bituminous paint specially suitable for waterproofing and preserving the interior surfaces of cement or metal tanks used for the storage of drinking-water.

Surfaces coated with bituminous

compositions may, even though considerably weathered, cause trouble if subsequently coated with oil paint. It is always wise to make a test by coating a small area and noting the result. Where the old composition is chemically active, it delays drying, and frequently "bleeds through" (discolours) the new paint. In such cases it is necessary to seal up the old material by coating with knotting, aluminium or other metallic paint, or with one of the proprietary sealing solutions, before proceeding to apply oil paint.

Cellulose paints and lacquers are sometimes used for the decoration of interiors, their silky finish and quick drying properties being valuable and attractive qualities. It should, however, be realised that the solvents employed in their manufacture are capable of dissolving any oil paint previously applied. It follows, therefore, that the best results will be obtained by working directly upon the clean wood or plaster surface and employing the appropriate undercoatings and finishes. For all except very small areas spray application is necessary.

It is a curious fact that a pound of good-bodied varnish covers twice the area of an equal weight of ordinary lead paint, although the former is much more difficult to apply. A comparison of the areas covered per gallon shows considerably less variation, any increase in the amount of pigment reducing the flow and spreading power. Table I on page 242 gives the average weight, volume and covering power of various materials—details which are of the first importance to all estimators.

In the paintshop and store it is essential that a methodical and orderly arrangement of material and equipment be maintained (Fig. 1). Ample shelving accommodation should be provided and stocks should be kept at an efficient working level.

Care of Tools

It is characteristic of thorough craftsmen that they exercise the same care in the maintenance as in the selection of their equipment. Good tools are a pleasure to work with, and much time and energy will eventually be saved by purchasing only the best of each type. In the case of cutlery, it will be realised that rust is likely to cause considerable damage unless care is taken to clean and dry the

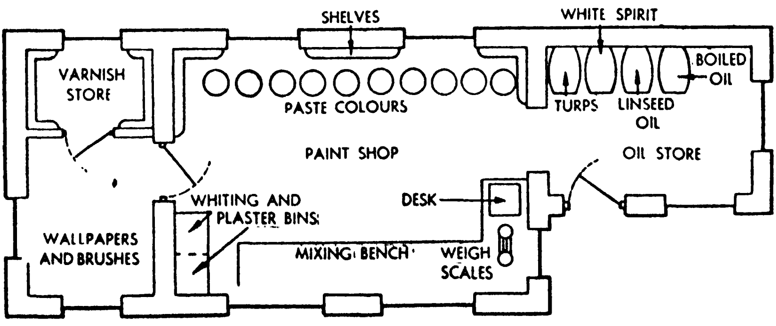


Fig. 1. Plan of a compact lay-out suggested for the up-to-date paintshop and store. The provision of ample shelving accommodation is of great importance.

Type.	Weight per gallon.	Area covered per gall.	Area covered per lb.
PRIMING PAINTS: WOOD OR PLASTER SURFACES			
White lead . . .	27 lb.	80 sq. yd.	3 sq. yd.
Lithopone . . .	21 ,,	100 ,,	4¾ ,,
PRIMING COAT: IRONWORK			
Red lead . . .	30 lb.	80 sq. yd.	2½ sq. yd.
Red oxide . . .	18 ,,	110 ,,	6 ,,
INTERMEDIATE COATS			
White lead . . .	28 lb.	112 sq. yd.	4 sq. yd.
Lithopone . . .	24 ,,	144 ,,	6 ,,
Red oxide . . .	19 ,,	145 ,,	7 ,,
Red lead . . .	33 ,,	100 ,,	3 ,,
FINISHING COATS: READY MIXED			
Enamel paint . .	14 lb.	85 sq. yd.	6 sq. yd.
Flat enamel paint . .	12 ,,	120 ,,	10 ,,
Oil varnish . . .	9 ,,	95 ,,	10½ ,,
Aluminium paint . .	11 ,,	120 ,,	11 ,,
Bituminous paint . .	12 ,,	35 ,,	3 ,,
Oil-bound distemper .	6 sq. yd. per lb. of stiff colour.		
Size-bound distemper .	7 ,, ,, ,, ,,		

Table I. Details of priming paints indicating the average weight, volume and covering power of the various materials. On no account must ready-mixed enamels, enamel paints or oil varnishes be thinned unless in accordance with manufacturers' instructions, otherwise the fine balance of the material will be altered.

metal parts immediately after use. An occasional rub with dry pumice stone will keep both blades and handles clean and bright as new.

Scrapers, chisel knives and stopping knives should be of finely tempered steel, with thin blades, flexible towards the tip and secured by at least one rivet through the handle. Good types are illustrated in Fig. 2. Knives of third-rate quality frequently twist on contact with the blow-lamp flame, or are too thick and coarse to make a clean job when removing paint or wall-paper. They are, however, useful for scraping and chipping rusted ironwork and similar rough work which quickly spoils the finer tools.

Shave hooks are necessary when removing paint or varnish from moulded or carved surfaces. Three types are available, the heads being heart-shaped (Fig. 2), triangular (Fig. 3), or with a variety of interchangeable blades (Fig. 3). The first named appears to be the favourite among painters. These are kept in good condition by sharpening the edges from

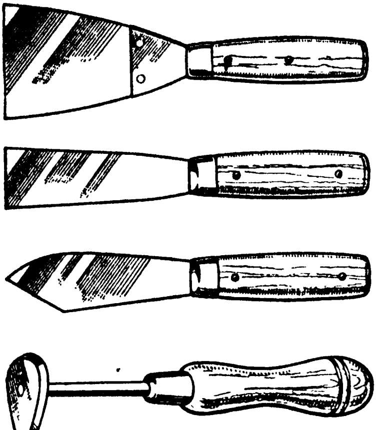


Fig. 2. Selection of tools from the painter's kit. (*Top to bottom*) Broad scraper; chisel knife; stopping knife; shave hook (heart shape).

time to time with a file, and it will be found that the blade is quite as useful when, after many years of service, it is reduced in size.

Trowels used for "making good" small repairs to plaster surfaces are the gauging trowel (Fig. 3), and the pointing trowel (Fig. 4); the latter being particularly useful when working in positions otherwise inaccessible. The blade will eventually become pointed, as in Fig. 4, and in this form it is handiest for angles.

The plastering trowel (Fig. 4) simplifies the job of levelling up any repairs which may be too large for the gauging trowel. A hawk or handboard, about 13 in. square, as in Fig. 5, forms an important item of equipment, and should be properly cleaned immediately after each job.

In dealing with the care of brushes, several considerations must be taken into account—viz., the type of hair or bristle employed; its method of attachment; the purpose of the brush, and whether in constant or intermittent use.

New brushes should be stored in a dry atmosphere, well away from heat, which might cause the

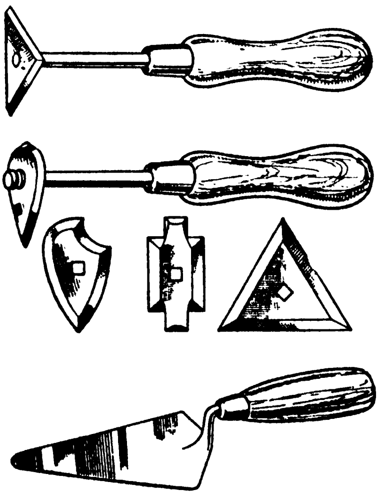


Fig. 3. Further selection of tools. (*Top to bottom*) Triangular shave hook; shave hook with interchangeable heads; gauging trowel.

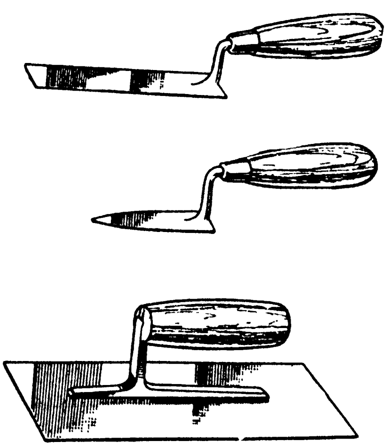


Fig. 4. (*Top*) Pointing trowel; (*centre*) handy tool which is generally employed for applying stopping to angles; (*bottom*) plastering trowel.

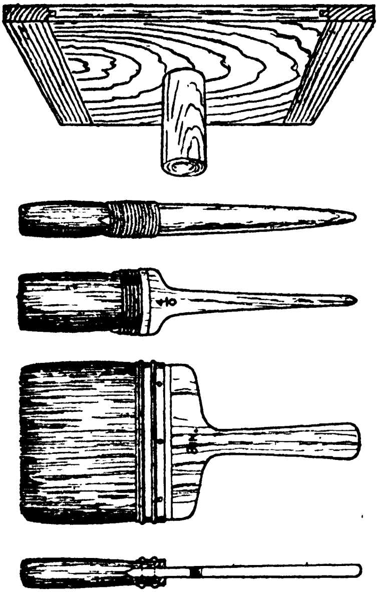


Fig. 5. (*Top to bottom*) Handboard or hawk; string-bound sash tool; wire-bound ground brush; distemper brush and section.

handles to shrink from the adhesive in which the bristles are set. It is also advisable to take precautions against damage by moth, the usual deterrent for this purpose being a liberal sprinking of flake naphthaline.

Certain types of brush require soaking in water for 15 minutes before being put into use for the first time; others require "bridling"—*i.e.*, binding with string, to control the extra length of bristle and assist in preserving a good shape. Fig. 5 shows sash tools and ground or pound brushes, both of which require bridling and soaking. Generally speaking, those brushes with a central core of wood, and they include ground, and all types of distemper brushes (Fig. 5), are soaked, in order to swell the wood and tighten the binding.

Flat paint brushes have rapidly superseded the ground brush for general house-painting purposes. They are—or should be—made from sorted hog's hair, set in rubber cement, and, being of the right length for immediate use, do not require bridling or "wearing in" before being used upon high-class work. Examples of these brushes are shown in Fig. 6. Poor-quality brushes are often cut to the required length and bevelled by abrasive action, treatment which can never produce the soft springiness of full length, naturally-tapered hog's-hair bristle as shown in Fig. 6.

Paint brushes which are regularly in use are usually kept in containers, containing just sufficient water to cover the bristles only.

A better method is to suspend the brushes either by wires passed through the handles, as in Fig. 6,

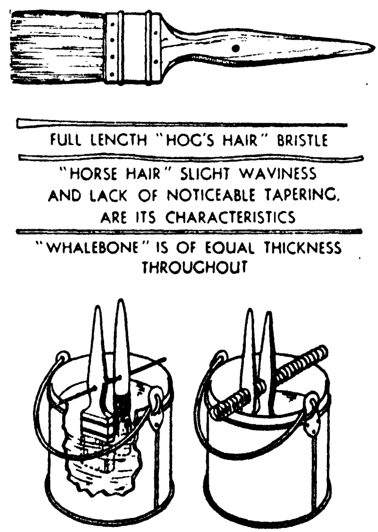


Fig. 6. Flat paint or enamel brush; types of hair; two methods of suspending paint or varnish brushes.

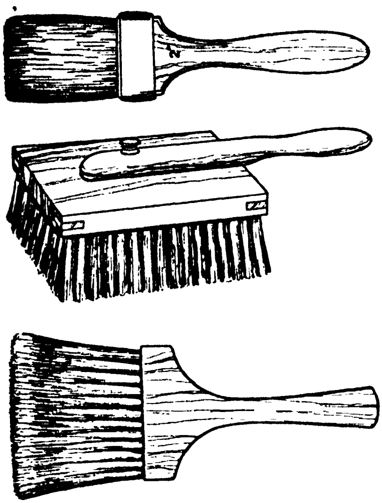


Fig. 7. Seamless ferrule varnish brush; stippling brush; badger-hair softener.

or by a spring which clips several at a time.

Fig. 7 shows the best type of varnish brushes, which are those with seamless metal ferrules which do not harbour dirt or grit. These are kept suspended in a mixture of oil and turpentine, preferably in a covered container.

If brushes have to be laid aside for some weeks, they should be rinsed in white spirit, and thoroughly washed in hot water and soap. Soda has a damaging effect upon the bristles. All other brushes should receive the same treatment immediately after use, taking care, in the case of stipplers (Fig. 7), badger softeners (Fig. 7) and other expensive brushes not to wet the woodwork unnecessarily and not to dry the brushes in too warm a place.

During recent years rubber has been used to replace hog's hair in a variety of fine, medium and coarse rubber stipplers, as shown in Fig. 8. These produce a good range of broken-colour effects when used upon wet paint, or varying degrees of real texture when used for stippling plastic paint.

Vegetable fibre brushes are too coarse for any form of painting, but they have the advantage of cheapness, and when caustic soda is to be used, either for cleaning purposes or for the removal of paint, fibre withstands the action of the alkali, while hog's hair would speedily be destroyed.

Principles of Painting

Although interior and exterior work present different problems, three essentials are common to both situations and must be observed at all stages to ensure the satisfactory progress and completion of a job.

(1) *Surfaces* should be chemically inert, or treated in such a manner as to render them inert and safe, before oil paint is applied.

(2) *Absolute dryness* of the surface at the time of painting is of the utmost importance. Imprisoned moisture not only prevents proper cohesion, but sooner or later will vaporise and form unsightly blisters. In the case of new surfaces it is highly probable that irreparable damage would result from painting upon damp wood or ironwork. In the first place, rot would be encouraged, and in the latter case rust would

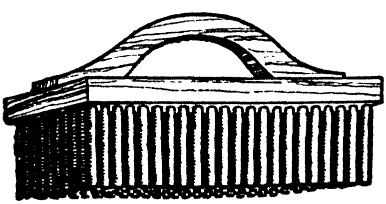


Fig. 8. Coarse rubber stippler.

commence and continue beneath the paint, defeating the primary object of painting.

(3) *Cleanliness* is essential to proper adhesion and normal drying action, hence the specification clause "wash off, prepare and paint, etc.". As far as painting is concerned, dirt may be defined as the sooty deposits met with in towns as dust and any form of grease or grime, including that caused by fumes from oil stoves or cooking; even finger-marks on paintwork must be included, because oil paint fails to dry thoroughly upon such surfaces.

Cleanliness is also meant to imply that surfaces shall be free from all loose, powdery or flaking material such as distemper, and from paste, paper or size remaining from some previous job.

Preparation of Grounds

Good preparation must always aim at the production of a hard, firm ground, with sufficient "key" to ensure the proper adhesion of the paint. New material, which is naturally absorbent, provides ample "key" or grip, by allowing the paint to penetrate well into the surface. On old work, key is formed mechanically by the use of abrasives, or by washing down with sugar soap or washing soda, either of which removes both dirt and the face of the paint itself, exposing a new and slightly roughened ground.

Defects arising directly from the non-observance of these elementary precautions, or by slipshod methods of preparation, may take time to manifest themselves, but they will eventually have to be made good at considerable expense.

Cracking usually results when, for some reason, the undercoats remain softer than the final surface coat. This may be due to an excess of oil, the presence of dirt or grease, or insufficient time allowance for proper hardening between coats. In addition to sound preparatory work it is advisable to observe the popular rule of building up a sequence of coatings ranging from hard undercoats to more elastic finishes.

Peeling, chipping and flaking are frequently caused by lack of key between surface and paint. Any surface which is not absolutely firm and stable eventually breaks down under the weight of superimposed coats of paint. The presence of unstable substances such as size or size distemper, which are liable to perish, is just as conducive to flaking off as is the perishing of the binding agent in the paint itself.

Blistering, commonly attributed to the action of heat upon imprisoned moisture, may also be due to any of the causes already enumerated.

Exterior Painting

Exterior painting is obviously a seasonable job—that is, if the maximum results for the minimum of effort are to be obtained. In winter surfaces are rarely dry, and, in addition, the destructive effects of frost constitute a serious risk, so whenever possible it is wise to postpone operations until the late summer, when woodwork is bone dry and shrinkage has exposed all open joints. During this season, minor troubles such as showery or dusty conditions are usually temporary, and so long as the final coat is properly applied on the right kind of day, good results will usually follow.

The effects of weathering upon outdoor work are somewhat complex. The sun is probably the most destructive force, and the effects of the mildly acid rain, plus accumulations of city grime, are also damaging. Extremes of temperature cause a considerable amount of contraction and expansion, especially in woodwork, making it necessary to employ paints and varnishes capable of equal movement without breaking down.

One of the most durable finishes for exterior woodwork is the much-criticised grained and varnished job. This may be washed down, touched up and revarnished every two or three years; a job hardly possible on self-coloured paintwork. A really high-class varnish, applied to a properly prepared ground, has no superior for brightness and lasting qualities. It is, however, more expensive than the high gloss enamel paint finish.

Interior Painting

Except in factories and other positions where condensation may prove troublesome in winter, interior painting is an all-the-year-round job. Indeed, it is only logical to arrange for each class of work to be done in its proper season, thus easing the hard-pressed painter during the spring rush period, and, on the whole, obtaining greater satisfaction.

Destructive influences are usually limited to the action of condensed moisture, which has a definite solvent action upon the paintwork of window-frames in particular. In such positions, gloss paint of the "elastic" outside quality will prove far more resistant than the ordinary interior finishes, which are of a very much harder nature.

Hygienic requirements in hospitals, nurseries, bakeries, etc., are best satisfied by the use of gloss paints which permit washing down at frequent intervals. Upon such work, smoothness of surface becomes increasingly essential to appearance, to ease of maintenance and to the fulfilment of its primary object, sanitation. From a purely hygienic point of view, other materials would be classified in the following order of merit: (1) limewash, (2) oil-bound distemper, (3) size distemper, (4) wallpaper. Their matt finish does much to disguise irregularities of surface, but dryness is essential to their appearance.

Removing Old Paint

In the preparation of old paintwork it has frequently to be decided whether to remove completely or whether to rub down with pumice stone, pumice block or waterproof glasspaper, and only partly remove the old material. Where the paint is not badly cracked, blistered or overloaded, an abrasive will prepare the work cheaply and well. Pumice blocks containing soda quickly dissolve as well as smooth the old surface, and care must be taken to rinse very thoroughly so as to leave no trace of the alkali.

The complete removal of paint may be accomplished by either of three methods: by burning off; by means of solvents; by alkaline solvents.

Burning off is the quickest and cleanest method and has the advantage of leaving surfaces dry and in a fit condition for painting almost immediately. The majority of surfaces are usually quite undamaged by the heat of the blowlamp or acetylene flame, but

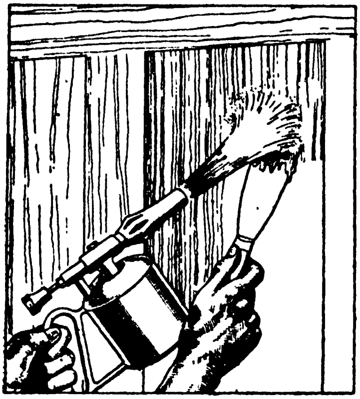


Fig. 9. Petrol blowlamp in use.

it is obvious that stained and varnished work, cellulose finishes, and glass work, call for the use of solvent removers.

Blowlamps designed for use with petroleum (Fig. 9) are lighter in weight and develop a hot flame in less time than the paraffin type of lamp. It pays to use the very best fuel, as much time can be lost and trouble caused by the use of heavy spirit which does not readily vaporise. Acetylene burners (Fig. 10) are especially valuable for exterior work, as the flame remains hot and steady, even in a high wind.

The tools required are a 2½-in. scraper, a 1-in. chisel knife and a shave hook. When stripping a door, the flat areas are completed first, then the mouldings, taking great care not to allow the keen edge of the shave hook to damage their shape, and finally the whole of the process is repeated to ensure the complete removal of any remaining paint. The surface should then be quite smooth, free from scraper marks, and presenting a clean and, as far as possible, unscorched appearance. A light rub down with medium-grade waterproof glass paper, moistened with white spirit if desired, completes this stage of the preparation.

Spirit solvents enable all types of paints and varnishes to be removed without any discoloration of the underlying surface. During recent years improved varieties of both inflammable and non-inflammable solvents have enlarged the scope of these useful products. In order to reduce the speed of evaporation and thus increase their efficiency,

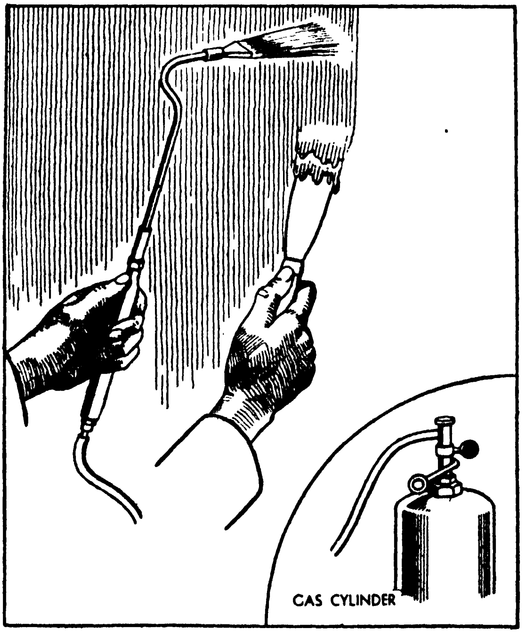


Fig. 10. Correct method of burning off by means of an air-acetylene blow-pipe.

some form of wax is frequently added, and traces of this, if allowed to remain on the prepared surface, would seriously interfere with the drying of the new paint. It is therefore necessary, after stripping, to wash the surface with white spirit and clean rags.

Caustic solvents of the caustic soda and lime, or soda and flour type, are certainly effective as cheap paint removers, but are dangerous to handle. The disadvantages associated with their use are: (*a*) the risk of burns from splashing; (b) the necessity for thoroughly washing off the least trace of the alkali afterwards, and where surfaces are of an absorbent nature, "pickling" (neutralising by means of a coat of 1 part vinegar to 4 parts of water), followed by a final rinse with clean water.

Knotting constitutes the first actual painting operation upon new woodwork, or woodwork stripped by any of the processes just mentioned, the object being to seal up the surface of each knot, thus preventing the resin content from discolouring superimposed coats of paint.

Patent knotting is universally employed for this purpose. Its drying speed and hardness enable work to be primed within half an hour of application. The quality of this material is particularly important and only genuine shellac knotting can be relied upon. Those wishing to make up their own solution will find the following recipe quite satisfactory:

Add 2 lb. of the best-quality orange shellac to 1 gallon of methylated spirit; shake well at intervals, and when dissolved (after about 24 hours) pass through a clean paint strainer. For the storage of this and similar spirit varnishes, only well-corked glass or earthenware bottles should be used, not containers made of tin.

For convenience, knotting is despatched to the various jobs in half-pint bottles. A clean pastepot, complete with brush, serves the purpose admirably. The knotting is applied so as to cover about ¼ in. beyond the area of the knot, the brush being on the dry side to avoid too heavy a coating, which might show through the finished work as an undesirable form of relief. It is preferable to give two thin coats rather than one thick one.

Priming, or first coating, of unpainted surfaces brings us sharply to a realisation of certain obvious differences which concern not only the various materials, their position and function, but also the degree of porosity, or the reverse, presented by each. Absorbent surfaces usually assist the drying of paint, others, such as glass and the impervious metals, are neutral, but materials such as teak and Columbian pine are definitely anti-drying and require special treatment before oil paint is applied.

Objects of Priming

The object of priming is threefold: (1) to obtain a good firm grip on the surface coated; (2) to check any porosity; (3) to provide adequate key for later coats. In the case of porous grounds a thin oily coating will penetrate into and saturate the surface sufficiently to meet all three requirements, but where no porosity exists it will be necessary to ensure the maximum amount of grip by using a highly tenacious paint medium, preferably a good elastic varnish, instead of linseed oil, and, where possible,

Fig. 11. Stopping must be pressed firmly into all cracks and holes, finally levelling off with the flat edge of the knife.

by lightly scoring or scratching the surface with emery paper.

To simplify classification, the types of surface are arranged under the following headings: (1) non-porous; (2) slightly porous; (3) porous; (4) very porous (Table II). Cast iron and special materials are dealt with separately.

Teak and Columbian pine should be primed with a mixture of equal parts japanners goldsize and turpentine, or, alternatively, with equal parts knotting and methylated spirits. As either forms a good sealing coat, no pigment is required at this stage of the work.

Chemically Active Surfaces

Chemically active surfaces include green Portland cement and other forms of new plaster or cement which are naturally alkaline, or to which putty lime may have been added. Keene's cement is safe to prime within an hour or two of setting, but ample drying time must elapse before second coating, otherwise the imprisoned moisture will cause trouble. Yet another potential source of danger may be present in the form of any preliminary rendering of mortar containing Portland cement. This takes a considerable time to dry, and the moisture which exudes is quite capable of saponifying an ordinary oil paint.

Asbestos sheets are safe only so long as they remain free from

Type of surface.	White lead.	Red lead.	Varnish.	Linseed oil.	Turpentine.	Paste driers.
(1) Non-porous, as glass and polished metal	7 lb.		6 lb.		1 lb.	½ lb.
(2) Slightly porous, as hardwood and burnt off work . .	14 ,,	1 lb.		1½ pints	1½ ,,	½ ,,
(3) Porous, as deal and other softwoods	14 ,,	½ ,,		2 ,,	1 pint	½ ,,
(4) Very porous, as new plaster, wallboard, asbestos sheets, etc.	14 ,,	½ ,,	Boiled oil. 1 pint	2 ,,	1 ,,	½ ,,
Cast iron and ferrous metal .	—	14 lb. Red oxide.	2½ pints	1 pint	½ pint	—
Cast iron, alternative coating .	—	14 lb.	2 ,,	2 pints	1 ,,	1 ,,

Table II. Composition of priming paints and types of surface on which used.

water; it is advisable, therefore, to paint the back and edges before fixing if doubt exists as to the absolute dryness of the position they are to occupy.

Surfaces may be tested by coating a small area with paint made from prussian blue, a colour which is speedily destroyed by active alkaline matter. It is not sufficient to neutralise an alkaline surface merely by washing down with dilute vinegar and then proceeding with oil paint. Obviously, the better method would be to prime with one of the proprietary, unsaponifiable, sealing solutions, and then to apply a rubberised paint, or, if the surface happened to be unfit even for this treatment, the whole job should be completed, as a temporary measure, with oil-bound distemper.

Stopping is another of those trade terms describing both the substance and the process in which it is employed. Minor repairs to plaster surfaces, whether new or old, may be stopped or filled with Keene's cement, plaster of Paris and putty lime; or with Alabastine, a handy proprietary filler. The stopping is applied after the completion of other preparatory work, all crevices being thoroughly wetted with clean water to delay drying and assist adhesion. Either a 2-in. scraper or small trowel will do the job admirably.

In the case of woodwork, wallboards and asbestos sheets, stopping is held over until after priming. In the two latter instances it is only necessary to prime about 2 in. in from each joint, the object being to use paint as a means of ensuring the adhesion of the stopping.

For nailholes and cracks in woodwork a more elastic composition is necessary. Ordinary linseed-oil putty is used for common work, but its slow hardening qualities and lack of smoothness make it unsuitable for facing-up the very shallow depressions so frequently met with. For these, white lead putty, a mixture of 1 part white lead to 4 parts putty, is preferable, but for best work the rapid hardening "hard stopping" is required. A reliable mixture is as follows: take equal parts by bulk of white lead in oil, whiting ground in turpentine and dry white lead ground in japanners goldsize; mix until free from grittiness. This works equally well with either the stopping or chisel knife, as shown in Fig. 11.

Undercoats and Varnishes

The priming coat on absorbent surfaces should dry with a rather patchy appearance, some parts being shiny, others matt. A dead flat finish would indicate that porosity has not been adequately checked, and too much gloss points to lack of penetration, a feature associated with the use of thick priming paint. It is safer to apply paint too thinly than to "pile it on" in an endeavour to save a coat. Thick heavy coats are apt to dry on the surface, but remain soft underneath.

The number of coats required must always depend on several factors. Obviously a sufficient number of undercoats must be applied to reduce porosity, obliterate or hide all knots and produce the colour desired. Where the finish is dark in tone, a dark grey priming coat would enable work to be completed in three coats—*e.g.*, grey priming, green semi-gloss undercoat, and green gloss enamel

paint finish. At least two coats are required after stopping, otherwise some difference in colour will occur.

A four-coat job is advisable where new wood or other absorbent surface has to be finished in pale tints. It will be found that a pink priming coat hides the knots in woodwork quite as effectively as two coats of white paint, and two coats of white upon a pink primer appear more solid than would be the case if a white primer was used. Furthermore, it is well known that paint becomes slightly less opaque within a month or two of its application, and any initial defects become more obvious.

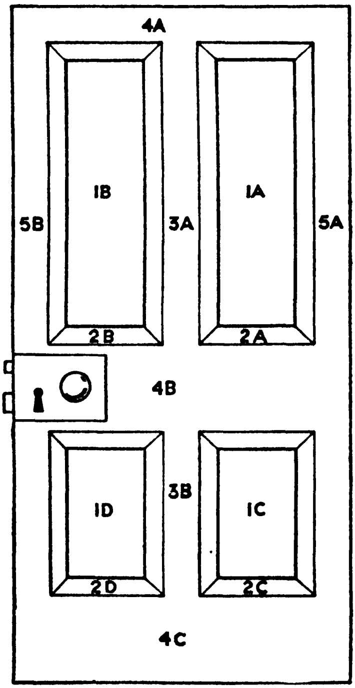


Fig. 12. Correct order to be followed when painting a door. Commence with top right-hand panel 1A, then 1B, 1C and 1D, before painting the mouldings in the order indicated.

Previously painted surfaces are frequently prepared, stopped and painted one or two coats of a similar colour, with good effect. In such cases the stopping must be touched up and brought forward to the same condition as the remaining surface before the whole is finally coated.

Brushwork

Brushwork differs considerably according to the type of material used. Undercoats, for example, are applied sparingly, while flat finishes require a more generous coat, and glossy finishes require a really good flowing coat. It is seldom necessary to dip more than ½ in. into the paint, tap the brush lightly against the sides of the paint kettle to remove surplus colour and, in the case of undercoats, spread each brushful to the fullest extent before taking another dip. When an area of about 3 ft. deep by 2 ft. wide has been evenly covered, "lay off" lightly in a perpendicular direction, then "cross" the work with horizontal strokes, and finally "lay off" vertically with the lightest possible pressure.

When properly executed, the work is perfectly even, and quite free from brushmarks. A coarse and ropey appearance is evidence of bad workmanship, the use of an old or coarse brush, an overloaded brush, too much pressure, or paint of too thick a consistency.

Order of Application

On large surfaces it is particularly necessary to plan the order of painting so as to keep the edges alive (wet) until the adjoining area is coated. In the case of walls this is accomplished by commencing

at the top left-hand corner, coating a strip about 2 ft. wide and completing this down to the skirting, then repeating the operation without pause until the whole wall flank is covered. Where the height exceeds 9 ft., the job calls for an extra man. Doors and panelled surfaces are more easily controlled, the panels being coated first, then the mouldings, and finally the muntins, crossrails and stiles (Fig. 12).

Finishing coats are applied in the same manner except that a liberal coat, particularly in the case of gloss finishes, will be necessary. Many proprietary finishes, both glossy and matt, are of the flowing type; these are capable of floating or levelling out after application, leaving no sign of brushmarks. Matt finishes are often stippled to produce an extremely fine texture which is also free from brushmarks (Fig. 13); furthermore, by distributing the paint in a perfectly even manner, "runs" which are due to uneven application, rarely occur. Table III (p. 254) shows the composition of undercoats and finishes.

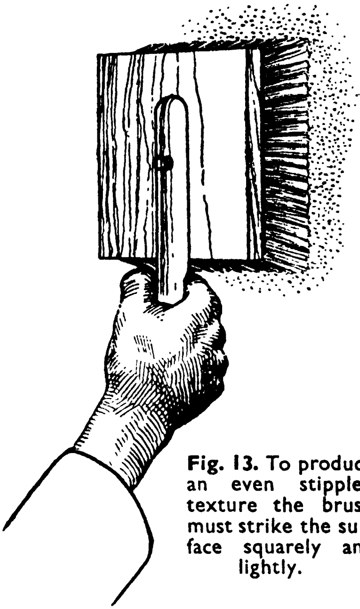


Fig. 13. To produce an even stippled texture the brush must strike the surface squarely and lightly.

Varnishing

The essentials of a good varnishing job are similar to those governing the application of gloss paints. Grounds should be non-porous, hard, smooth, clean, dry and of the eggshell gloss type. Whenever possible, work should be varnished within a day or two of painting, otherwise dirt or grease may accumulate and cause "cissing" (bare patches caused by grease repelling the varnish). This fault may result from the use of low-grade turpentine substitute, and where this trouble occurs, the remaining painted surfaces should be leathered down with fullers earth in water, either a clean sponge or washleather being used for its application.

A dry surface and a dry atmosphere are important. Warmth, although desirable, cannot always be controlled, but varnishing late in the day can at least be avoided as, at a critical stage of drying, this exposes the work to the sharp fall associated with night temperature. Chills, fog or moisture may affect the newly applied varnish and cause the white, misty appearance which is commonly known as "blooming".

Absolute cleanliness of brushes, varnish kettle and surroundings will go far towards avoiding unsightly dust specks on the finished work. Exterior work may have to be left until suitable conditions prevail, for it would obviously be inviting trouble to apply varnish on a windy day.

COMPOSITION OF UNDERCOATS AND FINISHES

(*a*) EXTERIOR WORK.

	White lead.	Varnish.	Linseed oil.	Turpentine.	Paste driers.
General undercoat .	14 lb.		1½ pints	1½ pints	¾ lb.
Eggshell gloss paint.	14 ,,	½ pint		1¾ ,,	¼ ,,
Oil gloss finish .	14 ,,	¼ ,,	2 ,,	¼ pint	½ ,,

(*b*) INTERIOR WORK.

	Zinc white.	White enamel.	Linseed oil.	Turpentine.	Zinc driers.
General undercoat .	14 lb.		1½ pints	2 pints	¼ lb.
Eggshell gloss finish	14 ,,	¼ pint		3 ,,	⅛ ,,
Oil gloss finish .	14 ,,	¼ ,,	2½ ,,	½ pint	½ ,,
	Zinc oxide in turps.				
Flat finish . .	14 lb.	¼ ,,		2½ pints	⅛ ,,

Table III. Details of composition of undercoats and finishes. Although white pigment is specified, this could be wholly or partly replaced by paste colour, to produce the desired hue. The eggshell gloss paint prepared from white lead is intended for use as the undercoat prior to a varnish or high gloss enamel finish. The addition of varnish or enamel improves the flowing qualities of the paints.

Varnishes are available in many varieties and degrees of colour, but none is absolutely white. French oil and White Coburg are suitable for use upon pale tints, but the medium-toned Copal varnishes are in general demand for average work. Synthetic varnishes are particularly durable upon exterior work, those of the quick-setting type being very resistant to rain within three hours of application.

Flat and eggshell flat varnishes are for interior use only. They are usually applied over a coat of ordinary gloss varnish, which supplies the required durability.

Types of Distemper

Broadly speaking, there are two distinct types of distemper; (*a*) oil-bound, the only type which can be used for both outside and inside work, and (*b*) those of the glue-size or casein-bound classes. Type (*a*) contains as binding agent either an oil or bituminous emulsion, and is, therefore, if thinned with petrifying liquid in accordance with manufacturers' instructions, the true washable distemper.

Casein-bound distemper contains a small proportion of lime in addition to whiting and other pigments. Water is the only thinner required. Casein plus lime forms an insoluble binding agent, consequently the material is slightly washable—a quality which is naturally reduced by over-thinning.

Size distemper is cheap, and is easily washed off when not required. Its preparation is simple, and consists of four operations, as follows:

Mix the whiting to a stiff con-

sistency with water; add the necessary tinting colours, which must be lime resisting and previously mixed with water; sieve through a copper-gauze strainer; add sufficient glue-size, approximately one part to two of distemper, to prevent the colour from rubbing off.

Surfaces should be washed and scraped to remove all loose or flaking material and defective plaster made good. Damp places should be cured at the source and old stains sealed with a coat of flat paint, thin knotting or oil-bound distemper, to prevent them bleeding through. Oil-bound distempers require no special undercoat, but size distemper needs an undercoat of *claircolle*, *i.e.*, size, plus 15 per cent of the finishing colour, to even up surface porosity and colour. Previously painted surfaces form unsuitable grounds unless hung with lining paper.

Drying Difficulties

All distempers dry quickly, therefore, if the edges are to be kept alive, it is imperative that the work be executed as speedily as possible. By regulating ventilation—closing windows and doors until a room is completed—and by using an 8-in. flat brush, work is more easily controlled. Oil-bound distemper works smoothly under the brush and allows time for crossing and laying off as in oil painting, but size distemper dries so rapidly that first-time methods, involving the use of a full brush and laying off in all directions, become necessary.

Limewash in its simplest form is prepared by diluting either putty (slaked) lime or quicklime with the required amount of water. After application, the lime is slowly carbonated and rendered insoluble. It makes the cheapest and most hygienic form of white or colour wash, and is particularly useful for cellars and warehouses, where absolute dryness of surfaces is the exception rather than the rule. When required for exterior use, weather-resisting properties are improved by the addition of either boiled oil, tallow or soft soap, thus forming an oil emulsion.

Paper-hanging

In paper-hanging, surface preparation must be identical with that specified for size distempering, except that a coat of size is used in place of claircolle to cancel or stop porosity upon plaster and other absorbent surfaces. Portland cement and asbestos are sealed by coating with oil-bound distemper, which is sufficient to prevent undesirable alkaline action from being set up by the wet paste.

Painted or varnished surfaces are rubbed down to a matt condition, then sized, and hung with lining paper, applied horizontally. This treatment prevents any condensation of moisture which might otherwise percolate through a wallpaper during unfavourable weather conditions. Previously papered surfaces should be thoroughly soaked with hot water and stripped with the broad scraper, then washed down, stopped and sized.

Common Adhesives

Adhesives requiring only the addition of water are now obtainable. Such materials are undoubtedly useful, but on jobs where boiling water is available, the paste made from common flour or starch is more economical, more tenacious and has superior sliding

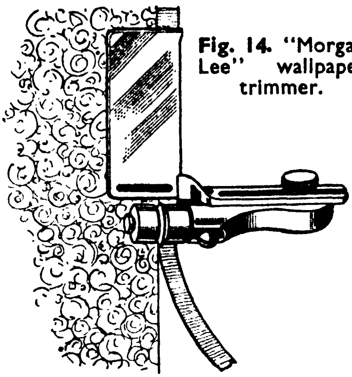


Fig. 14. "Morgan Lee" wallpaper trimmer.

properties. By beating up 2 lbs. of flour or 1 lb. of starch in a little cold water and then stirring in 1 gallon of vigorously boiling water, a very stiff paste results. This may subsequently be thinned out to make 1½ gallons.

A roll, or piece of English wallpaper is 11½ yd. long by 21 in. wide; therefore, given the height of a wall, plus a few extra inches for matching, one can ascertain the number of lengths obtainable per roll. By measuring the number of 21-in. widths required to girth a room, and dividing by the number of lengths obtainable per roll, the number of rolls of wallpaper required for the room is determined. The possibilities of using short ends of rolls for positions over doors and beneath windows should receive due consideration.

Each room lot should be carefully examined before trimming to see that all rolls are of exactly the same shade. Odd pieces can sometimes be used upon the smaller walls flanking a chimney breast, but the joins between papers of different tone must obviously occur at the angles of a room.

Trimming off the edge joints may be executed by scissors or by a patent trimmer such as that shown in Fig. 14. Both edges should be neatly removed, except in the case of very cheap papers requiring a lap joint of about ⅛ in.

Method of Working

Joints are considerably disguised by commencing at the lightest, and finishing at the darkest parts of a room; a procedure equally applicable to both ceilings and walls. In the latter case it is better to work systematically away from the window in the directions indicated in Fig. 15 (left), finishing at the doorway. Failing this, it would be equally convenient to finish at the angle marked X.

Where there is a straight cornice moulding, each length is applied from right to left, as shown in Fig. 15 (*right*). The edge of the cornice serves as a guide for the first length. In the absence of a cornice, a line must be struck, with chalk and string, 20½ in. away from the wall.

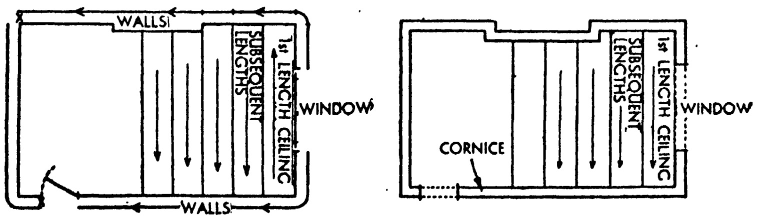


Fig. 15. (*Left*) Plan of room without cornice moulding. (*Right*) Straight cornice which enables all lengths of ceiling paper to be hung in the same direction.

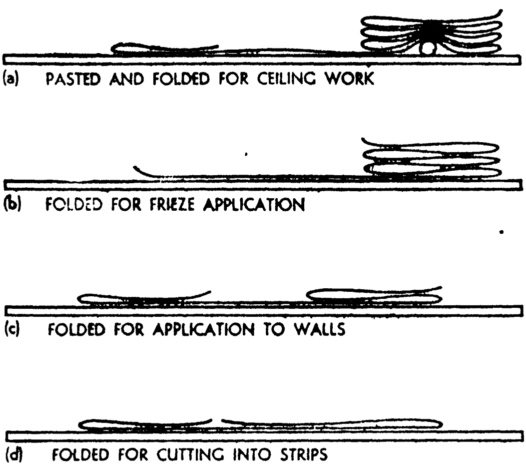


Fig. 16. Methods of folding wallpaper for the various purposes for which it is used.

This serves as a guide-line for the first length which is hung from left to right, the remaining lengths being applied as illustrated in Fig. 15 (*right*).

With the paper pasted and folded as in Fig. 16 (a), supported by a roll held in the left hand, the right hand is free to attach and slide the first fold into its position on the ceiling. Creases are brushed out with the papering brush as fold after fold is released. The direction of the brushstrokes controls and influences the run of the paper, making it necessary to brush straight along the centre, before working crosswise towards the edges.

Friezes and papers hung horizontally, as illustrated in Fig. 17, are folded and applied in a similar manner to ceiling paper, except that a supporting roll is unnecessary. Surplus paper is neatly cut off at the ends, but in common with all wallpapers and —in the absence of a cornice — ceiling papers, about ½ in. extra should be allowed to wrap over at the angles.

Strict cleanliness is essential throughout. Not only the hands, but the pasteboard and other appliances must be kept clean and dry. Any paste or fingermarks may be lightly sponged off if they are tackled immediately. Paintwork requires the same treatment, for paste has a very damaging effect upon all types of painted or varnished work.

Just as the angles of a room are seldom perfectly plumb, it will be found that window-frames also vary in this respect. It follows, therefore, that the plumb-bob and line must be in frequent use,

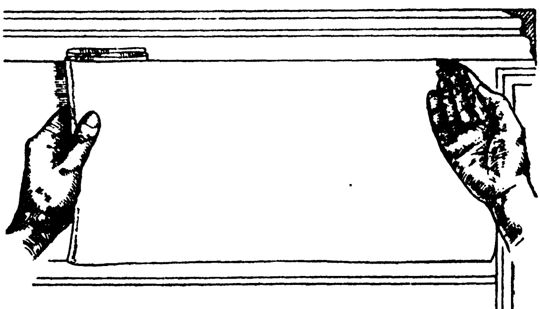


Fig. 17. Papering the frieze. In this case the paper is folded and applied in the same manner as for the ceiling but a supporting roll is not necessary.

(B.R.)

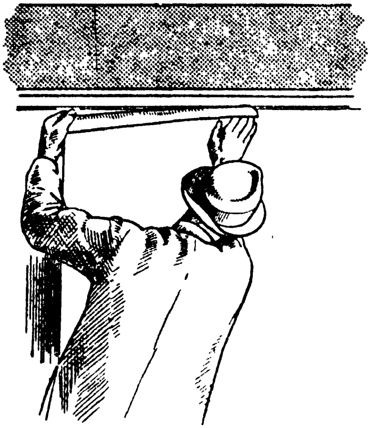


Fig. 18. Hanging wallpaper. Top edge of the paper is placed against the plumbed line and the opposite edge is held away from wall. By raising or lowering the hand, therefore, the whole can be readily swung to the right or to the left as desired.

especially to plumb the first length on each wall. Where the window-frame is found to be "out of plumb", a perpendicular line struck 21 in. away will considerably simplify the job of hanging the first length.

With the paper properly pasted and folded (Fig. 16 (c)) climb the steps and place the top edge of the paper against the plumbed line. The opposite edge is held away from the wall so that by raising or lowering the hand, the whole may be swung to the right or left as required. This position is maintained until 3 or 4 ft. of length of the matching edge are accurately placed, as in Fig. 18, then the full width is brushed smoothly and firmly to the wall.

The lower half of the length is then unfolded and brushed straight down the centre, leaving the edges until the last. It will be found that by brushing in a slanting direction the paper can easily be pulled $\frac{1}{4}$ in. to the right or left, should this become necessary. Surplus paper is then marked in the top and bottom angles and finally trimmed off.

When negotiating angles, a length must be folded as shown in Fig. 16 (d), and a full-length strip of the required width marked and cut from the matching edge.

French Polish

French polishing is essentially a job to be executed under warm, dry and draught-proof conditions. The complete observance of these essentials will amply repay any trouble involved, but their non-observance will result in loss of time, reduced gloss and, very frequently, the white, misty appearance known as blooming.

The composition of french polish is identical with that of patent knotting; some polishers add 4 ozs. of gum benzoin, or gum sandarac, to heighten the gloss, but in both cases the basic substance is shellac, either orange or white, according to the colour required. This stock mixture is much too thick for application by the rubber, and although methylated spirit could be employed as a thinner, the purer "methylated finish", or "industrial alcohol" is much to be preferred.

New surfaces usually involve staining, grain filling, oiling in, bodying up and spiriting off. A certain amount of preparation may be necessary to produce a smooth, clean surface. This result can be obtained by glasspapering, always in the direction of the grain, or by means of a carpenters' scraper. Ink or other stains can be bleached out by several applications of oxalic acid solution, afterwards using a damp sponge to

remove any free acid. Nail holes and cracks are stopped with plastic wood and when hard the repairs are glass-papered smooth.

There are three classes of stains in general use: (1) chemical stains; (2) water stains; and (3) spirit stains. Chemical stains are solutions of lime water, soda, Epsom salts or dilute ammonia, all of which are colourless, but when applied to walnut, mahogany and similar hardwoods have the effect of darkening the softer parts of the grain, and so contrast is increased.

Water and Spirit Stains

Water stains include the specially prepared powder colours, the alkaline dyes, permanganate of potash and, for cheaper work, the semi-transparent pigments such as vandyke brown, mahogany lake, raw and burnt sienna, all of which mix readily with water and are used as warm solutions. This is to minimise raising the grain of the wood.

Spirit stains are specially prepared spirit-soluble dyes which penetrate deeply, dry rapidly and are remarkably clear. They do not raise the grain and have the advantage of mixing readily with the polish to form a coloured solution particularly useful for touching-up.

Filling is only necessary when working upon oak, mahogany, walnut and other similar woods with open pores. A mixture of whiting and turpentine, stained with pigment, either dry or ground in oil, is reduced to a creamy consistency and rubbed across and into the grain until all pores are filled. By using hessian or other stiff material, very little filler is left outside the pores, and within an hour the surface is fit to glasspaper and ready for oiling in: the latter involves a very sparing application of linseed oil, to check undue porosity.

Bodying up may commence with a coat of half-strength polish, applied with a camel-hair mop. This is glasspapered and followed by several rubbers of slightly thinner polish, using very little oil upon the rubber, until a really good surface is obtained. Adequate time should be allowed for the proper hardening of each coat, and, in the early stages particularly, glasspapering is necessary to smooth out the rubber marks. The rubber should be charged sparingly and manipulated in a series of constantly overlapping circles.

Spiriting off is commenced by a rubber of 1 part polish to 2 parts of spirit, applied in the direction of the grain. This removes previous rubber marks and produces a uniform gloss. To finish off use a clean rubber of spirit only.

Old Surfaces

When treating *old surfaces* a comprehensive specification covering all types and conditions of work would read as follows: wash down or strip off; make good all defects with plastic wood; touch up all repairs and bare places with coloured polish; body up, using coloured polish where the old work is faded; finally, spirit off.

The main difference between old and new work lies in the preparation. In the majority of cases a wash down with warm water containing very little washing soda will suffice to prepare the surface, but when the old polish has perished in places or has bloomed, its complete removal, either by spirit solvent or a strong solution of washing soda, is necessary.

CHAPTER 11

FENCES, GATES AND RAILINGS

TYPES OF TIMBER FENCE. COMPOSITION AND CONSTRUCTION. COMMON DEFECTS. REPAIRS TO FENCES. WIND PRESSURE. PLACING SUPPORTS. CONCRETE FENCES. STRAINING POSTS. METAL RAILINGS. DESIGN AND CONSTRUCTION OF WOOD GATES. BRACING. METAL GATES. WIRE NETTING SURROUNDS. GREENHOUSES. GLAZING AND CONDENSATION.

THERE are three main objects of a fence: (1) to define the boundaries of a particular piece of land; (2) to prevent access; and (3) to ensure privacy. Sometimes a fence may be intended to fulfil more than one of these requirements, and the design will, to a great extent, depend on the purpose. The materials used for fencing are timber, concrete and metal.

Timber Fences

Hurdle Fence. The simple hurdle, or wattle, fence is probably the cheapest form of timber fence, but is not likely often to be met with in connection with houses, unless it be as a wind screen to protect some delicate garden growths. It is frequently used to form a temporary pen for sheep.

Hurdle fences are made with small boughs cut in half lengthways, the half-boughs being interlaced horizontally round upright end and intermediate stakes, the end stakes being long enough to be driven into the ground.

These fences are usually made up in sections 6 or 8 ft. long, and 3 ft. high, and as they can be bought from most fencing contractors at a moderate price, it is better to obtain a new section if the fence has become dilapidated, rather than to attempt interlacing new boughs.

Post and Rail Fence. A much stronger type is the post and rail fence, but this is more likely to be met with in outlying fields than in close proximity to houses. It is composed of stout posts driven well into the ground, and three, or four, horizontal lengths of rails nailed to the faces of the posts. In better construction the rails will be found mortised into the posts.

Defects are most likely to occur where the rails pass across the faces of the posts, or where they enter the posts if mortised, as there is a likelihood of rain or general moisture getting down between the rails and the posts, causing the wood to rot. If the rails are nailed to the faces of the posts, the moisture may cause the nails to rust through, leaving the rails unsupported.

In repairing rotted rails with new lengths, galvanised nails should be used.

Cleft Fence. Another moderately cheap form of fencing is the

cleft chestnut fence. This is made up with small chestnut branches split into two and kept upright at intervals of about 6 in. with horizontal strands of galvanised wire. Two or three rows of wire are used, attached at the ends to thicker stakes, so that when the stakes are driven into the ground the wires keep the half-branches upright as illustrated in Fig. 1 below.

This type of fence is bought rolled up in a bundle, and the usual height is 3 ft. or 3 ft. 6 in. An advantage of this fencing is that it can easily be rolled up and re-erected elsewhere, but if this is done frequently the wires may wear and break. It is, however, easy to join on new lengths when repairs are necessary.

As the upright pales are passed through loops in the wires, new ones can easily be inserted.

Paled fences are most frequently found in residential localities, and may be either open or close paled, according to the purpose for which they are wanted. In positions where privacy is not the object so much as demarcation of boundary and prevention of intrusion, the open paled fence is suitable.

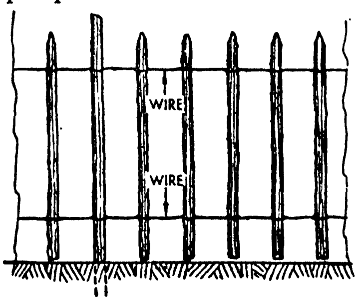
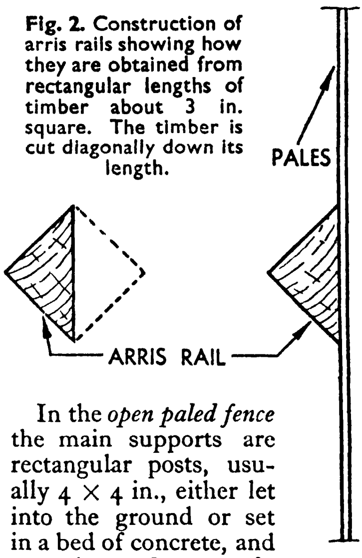


Fig. 1. Cleft fence. This type of fence is composed of chestnut branches split in two and arranged at intervals of about 6 in. Branches are held together by two rows of galvanized wire.

Fig. 2. Construction of arris rails showing how they are obtained from rectangular lengths of timber about 3 in. square. The timber is cut diagonally down its length.



In the *open paled fence* the main supports are rectangular posts, usually 4 × 4 in., either let into the ground or set in a bed of concrete, and spaced at 8 or 9 ft. centres. Two rails run from post to post, one near the top and the other near the bottom. The rails are preferably let into mortises in the posts, and may be either arris or cant.

Arris rails are obtained from rectangular lengths of timber, usually 3 in. square, by cutting them diagonally down their length, thus forming two lengths of triangular section, as shown in Fig. 2.

Cant rails are generally formed by canting, or chamfering, one face of a rectangular length of timber, often $2\frac{1}{2} \times 2$ in., fixed with the sloping chamfer on top. It will be noted that the shape of both types is such that rain will run off quickly.

The pales are commonly of $3 \times \frac{3}{4}$ in. timber, and are nailed vertically to the two rails, at equal distances from each other. Chestnut and oak are the favourite woods for pales, and these may be either sawn or cleft.

To avoid the somewhat monotonous appearance of a long level fence, the tops of the pales are sometimes cut to a shallow curve, sinking in the middle and rising to each post. Other variations are occasionally introduced.

Defects that may arise are similar to those occurring in close paled fences.

The general construction of the *close paled fence* is the same as in the open paled variety, but the pales are close together. Usually they are feather-edged and fixed to the rails so as to over-lap one another by half an inch or so. Common widths are 3 in., 4 in. and 6 in.

It is very desirable, in a fence of this description, to have a gravel board. This is a board, 9 or 11 in. deep and 1 in. or preferably 1¼ in. thick, running from post to post and attached to the posts so that the pales rest on the top of the board. This helps to support the pales and prevents them from sagging in the middle of the bays, due to their unsupported weight causing the arris rails to bend.

This can be stopped by small stub posts, about 2 × 2 in., driven well into the ground against the gravel board, which is then nailed to them. These stub posts should extend up to the lower arris rail, their tops being shaped to fit to the rail. Two stub posts in each bay are sufficient. They are illustrated in Fig. 3.

A gravel board also acts as a kind of retaining wall to garden mould that may get banked up against it, and which would rest against the pales if they extended to the ground without a board. In that case the weight of earth would probably push the pales out of place, as they are too thin to with-

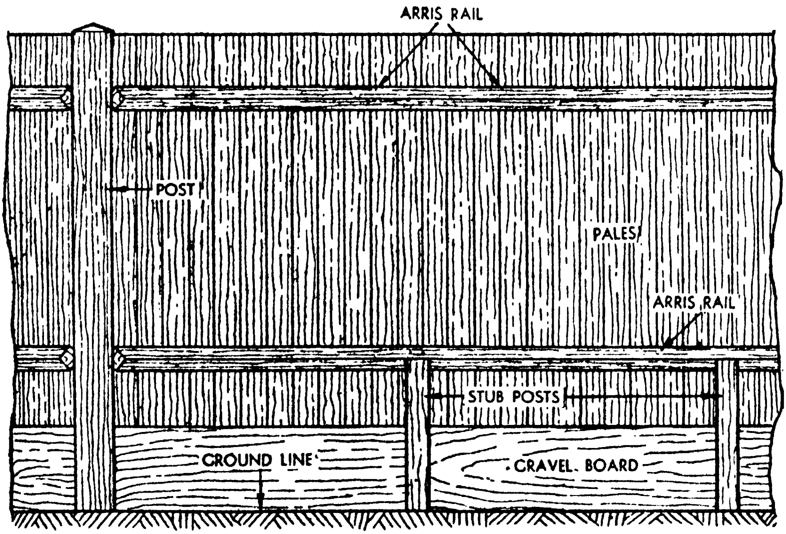


Fig. 3. Close paled fence construction. The pales may be feather edged and overlap by about ½ in. They rest on top of the gravel board which gives them some support and also prevents them from sagging in the middle of the bays. The gravel board is nailed to stub posts which should extend up to the lower arris rail.

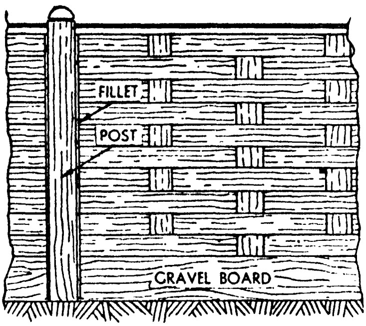


Fig. 4. Woven board fence in which the boards are woven alternately in front of and behind the vertical slats.

stand much side pressure. The three most common defects in a close paled fence are sagging, pales becoming loose, and rotting at the bases of the posts.

Loose Pales

Pales become loose because the nails, if not galvanised, will rust in time and break under the swaying movement caused by high winds. They may also shrink in width to such an extent that they no longer overlap, and there may even be gaps between adjacent pales. If it is desired to remedy this, the pales must be taken off and reset at a slightly wider overlap, to make room for nailing up a new pale to complete the bay.

Defects in the posts usually occur where they enter the ground, as the portion sunk in the earth is kept damp by the moisture in the soil, while the portion just above ground is alternately wet and dry, according to the weather, and this condition usually leads to rot. In extreme cases the post may break off at this point.

To resist wind pressure on the fence, posts should be let into the earth at least 2 ft., and their butts should preferably be left rough from the tree. The butts should always be well tarred or creosoted, or at least charred, as this helps to prevent penetration of moisture.

Even if the posts are wrought to a rectangular section for their whole length, and bedded in concrete, the ends should still be so treated, as the concrete will be damp owing to its contact with the earth.

Posts showing signs of decay may be stiffened by driving a short post into the ground, and projecting 12 or 18 in., and bolting it to the old post. This cannot be done if the post is bedded in concrete, as the new stub post could not be driven in near enough to the old post to make a close connection.

The top of the posts shows end grain, and if cut to a horizontal line moisture will rest on its surface and be absorbed by the fibres, thus causing a condition favourable to decay.

To prevent this a separate capping piece is sometimes fixed to the top of the post; otherwise, the top should be rounded, or shaped to a point, to throw off rain quickly.

Woven Board Fence. Another type of fence that is occasionally seen is the woven board, or slotted fence, in which thin boards are

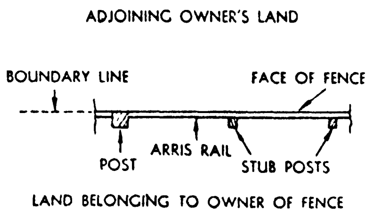


Fig. 5. When strengthening a fence with raking struts or stub posts these supports must be placed on the land belonging to the owner of the fence as shown above.

woven alternately in front of, and behind, vertical slats. The boards are usually about 4 in. wide and $\frac{1}{8}$ in. thick, the ends next the posts being kept in place by vertical fillets nailed to the posts on each side of the boards. The top of the fence should be finished with a capping extending from post to post, to make a neat finish and keep the tops of the vertical slats in place (Fig. 4).

New boards or slats can be woven in, if some of the originals break or split, as they may since they are rather thin.

It may be well to point out that if it is intended to strengthen a fence with stub posts, or raking struts, these must always be placed on the land belonging to the owner of the fence (as in Fig. 5). The general rule is that a fence is "nailed home"—that is, the nails holding the pales to the rails point towards the owner's land. The posts in the fence must not encroach on the adjoining owner's land.

Concrete Fences

Within comparatively recent years pre-cast concrete units have become available for fencing. In one variety only the posts are made of concrete, which is reinforced, and two or three horizontal rows of galvanised wire are stretched from post to post.

The posts at the end of each straight run of fencing are called the straining posts, and these are holed to allow long screwed eye-bolts to pass through. The wires are attached to these eye-bolts, and can be made taut by screwing up the bolts.

The tension of the wires tends to pull down the straining posts, and to prevent this a reinforced concrete strut is fitted into a slot made in the post for this purpose, the lower end being taken into the ground and supported by a slab of concrete buried at an angle, so as to act as a bearing plate giving a large area of pressure against the earth.

In addition, the straining posts are embedded in concrete buried in the ground, to give them greater stability.

To support the wires running from straining post to straining post, intermediate posts are set up at intervals of about 9 ft. or so. The intermediates are formed with holes, through which the wires are passed before being fixed to the eye-bolts on the end posts.

A variation of this type of fence is when steam barrel is used instead of wire.

In another form of concrete fencing the posts are grooved on two opposite sides, and thin pre-cast concrete panels are dropped into the slots. These panels are usually about $1\frac{1}{2}$ in. thick, and should not exceed 6 ft. in length, the posts being spaced accordingly.

As the panels are comparatively heavy, it is necessary to give the posts a firm seating in the ground by embedding them in concrete, for which purpose 3-ft. cube of concrete should be sufficient, and it need not be stronger than an 8 to 1 mix.

Concrete fences should last for many years without attention or repair, except, of course, for an occasional renewal of the wires or barrels.

Metal Railings

Except in highly ornamental and special work, metal railings are always of the open type, and therefore are not used where privacy is the chief consideration.

They are often used to fence off the pavement from the front gardens of houses, and for such positions they are made to more or less ornamental designs. Frequently they are fixed on top of a low brick wall finished with a stone coping, the brickwork being built up at intervals to form piers.

Metal railings take the form of two flat horizontal bars, in which are round or square holes at intervals of about 6 in. These bars are built into the piers, and vertical bars pass through the holes in the horizontal bars (Fig. 6).

To give additional stability, the design often includes a slightly thicker vertical bar passed through the stone coping and let into the brick wall, the hole in the coping being run in with lead around the bar. Or an angle iron may be bolted to the bottom rail and let into the coping.

Cast iron is seldom used for railings nowadays, wrought iron having taken its place, and if railings of this material are kept well painted they should require very little attention.

Rusting is the defect most likely to occur, especially where there is a lodgment for rain or moisture, for instance, where the upright bars pass through the horizontal flat section members, or where the uprights enter the dwarf wall. This rusting will gradually eat away the metal.

If a horizontal member has been broken, or eaten away by rust, it is possible to fix a short length of similar bar across the break, connection between the two bars being made by drilling holes through both and tightening with nuts and bolts. Alternatively, stirrup pieces may be passed round the upright bars on each side of the fracture to hold the severed parts together.

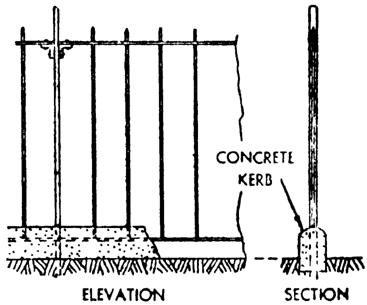


Fig. 5. Metal railings constructed with two flat horizontal bars through which vertical bars pass at intervals of 6 in.

When the vertical rails have rusted badly at the bottom, they can be pulled out and replaced with new.

When the railing is not set on a dwarf wall, but comes down almost to the ground between piers or standards, and is eaten away at the bottom, it is possible to form a small kerb in fine concrete, to embed the defective portions.

Wood Gates

Wood is the material of which the great majority of gates are constructed, and the defects that may arise are similar to those that occur in other wooden structures; but gates are specially liable to the effects of wet, owing to the fact that that they are exposed on all sides to the weather.

In gate posts, as in those supporting fences, trouble is likely to occur where they enter the ground, and if rot is allowed time to eat deeply into the wood, the post may break off at that part. If the decay is only slight, the bad wood may be cut out to a neat line and filled in with new wood cut to fit, but this does little more than

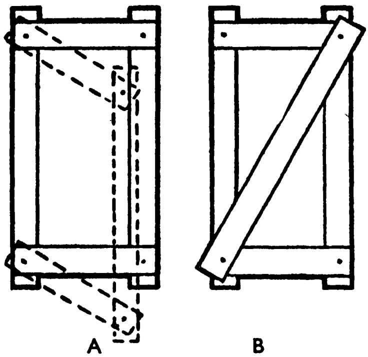


Fig. 7. Gate construction. *A*, Dotted lines indicate sagging in a non-triangulated gate due to defective fixing; *B*, triangulated gate held rigidly in position by means of diagonal cross brace.

restore the appearance, as the strength of the post remains impaired. This repair should not be looked on as restoring the post to its original condition, though it will preserve its life for some time longer.

Gate Design

The designs of gates are many and varied, but it is proposed to deal with them only from the constructional point of view. The essential point to remember is that a gate is a framework supported by the hanging stile alone, and if the constructional design is wrong the gate will be unable to support its own weight and will droop at the shutting stile end, thus opening the joints between rails and hanging stile.

A simple experiment will illustrate the theory involved. Cut four strips of cardboard and pin them at their corners so as to form a rectangle, as shown in Fig. 7, A. By holding one side firmly it will be found that the other three can be moved to change the rectangle into a diamond, and even to close it up. By adding another strip of cardboard diagonally across the rectangle and fixing it over the two pins, as illustrated in Fig. 7, B it will be found that the rectangle cannot be altered in shape.

In other words, the rectangle has been triangulated, or braced, and a triangle cannot be put out of shape, except, of course, by buckling or breaking under exceptional stress.

In the experiment the strips of cardboard were free to move about the pins, but if they had been glued, or more than one pin had been inserted at the corners, the rectangle would have retained its shape *so long as the fixings held.* That is the important point. In a gate that is not triangulated, or braced, it is essential that the rails should be well connected to the stiles, by mortising them and fixing with pins or dowels.

The position of the brace is important. Its purpose is to prevent the top rail dropping at the shutting stile end. Sometimes the brace is brought down to the bottom rail, as shown in Fig. 8 A. This is bad construction, because if the lower rail gives at its joint with the hanging stile, the brace will give also and let down the top rail.

Theoretically, the brace should be jointed to the stile clear of the bottom rail, but as this does not look elegant an effective compromise is to set it equally about a diagonal line drawn between the internal angles of the hanging stile and bottom rail and the shutting stile and top rail, as in Fig. 8, B.

If the gate has been designed with a middle rail, forming two rectangles, the lower can be braced, allowing the upper rectangle to

rest on the stiffened lower part. Triangulation can also be effected by tying instead of strutting. In this method a tie-rail is fixed from the top of the hanging stile to the bottom of the shutting stile and should extend over the full face of the stiles, to enable a strong attachment to be made.

Defects and Repairs

Rotting and shrinkage are the chief defects that will call for remedy. Rotted rails are best replaced by new, as it is difficult to make a satisfactory repair that is sightly. If the damage to a stile is in the upper portion, the defective part may be cut away and a new length spliced to the old. Shrinkage will affect the mortise joints, which may open and allow wet to enter. In such cases the gate should be clamped up tight, to get it back to its original shape, and the mortise joint re-wedged.

Angle-irons may be fitted to the meeting of stiles and rails, if the joints have parted, but this is not a sightly method. If the gate was hung on the usual pins and eyes, the substitution of strap hinges will help to keep the joints tight, and so strengthen the gate.

In an unbraced gate, dropping of the shutting stile may be prevented from recurring by fitting a brace; or, if the design does not easily allow this, by fixing a tie-rail on one side, or preferably both sides, as previously described.

Wrought iron is the material of which most metal gates are made, and as in essentials they are panels of iron railings hung on hinges, the previous remarks on defects in iron railings likewise apply to iron gates.

Iron gates are usually hung to brick or stone piers, or to metal standards. Sometimes the hinging is done by letting the end vertical bar of the gate rest in a metal cup let into the threshold. The gate is kept upright by means of two eyes passing round the same bar, and built into the pier.

Wire Netting

Wire netting is a suitable form of enclosure for tennis courts, and the best and strongest form is galvanised wire links (Fig. 9), intermeshed and stretched and supported from post to post by straining wires which can be tautened by means of screw eyes.

The posts at the corners, or at changes of direction, are stiffened by raking struts encased in the ground with concrete, the posts being similarly bedded. Intermediate posts are situated every 9

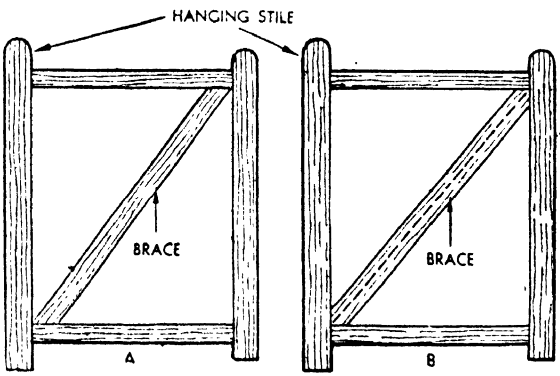


Fig. 8. A. Example of bad practice in which the brace is fixed from the top to the bottom rail. B. Correct method; in this case the brace is jointed to the hanging stile.

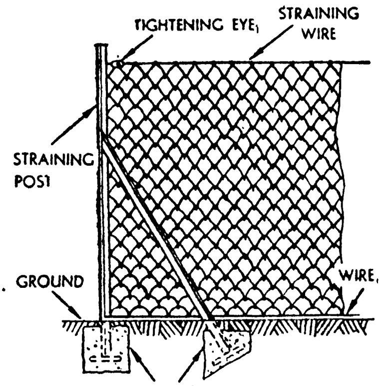


Fig. 9. Wire netting. Galvanized wire links intermeshed and stretched and supported from post to post by means of straining wires.

or 10 ft. and the straining wires pass through them.

The straining wires may snap in course of time, but are easily renewed. A long life may be expected for the mesh, and the posts should not give trouble if kept well painted.

Greenhouses

The purpose of a greenhouse is threefold: to let in as much light as possible; to protect the plants from cold winds; and to conserve heat inside the structure. The difference in temperature between the outside and the inside is therefore considerable in cold weather. This will cause the warm humid air inside to condense on the inner surface of the cold glass, and unless this condensation is dealt with it may find its way into the framework and set up decay.

Greenhouses are usually constructed in timber framing set on a low brick wall. The framing is upright to headroom height, and receives the lower end of the sloping roof, the whole being glazed.

The roof glazing bars are as narrow as necessary strength will permit, but the rebate receiving the glass should be reasonably wide so as to support the glass even when cut to a loose fit. The glass should not be cut tight between the bars, because it is exposed to considerable variations in temperature, and will expand and contract accordingly.

On the outside of the roof glazing the putty has not only to keep the glass in position, but also has to prevent moisture getting into the space between the edges of the squares and the perpendicular part of the bars. Cracks in the putty will allow water to collect in this space, and if the woodwork was not well primed, trouble from decay may occur. The puttying should therefore be renewed if badly cracked. The roof should not be constructed at an angle of less than 30 deg. to ensure that rain runs quickly down to the eaves.

On the inside, condensation on the glass will also run down and reach the eaves.

Condensation moisture from the glass will ultimately collect at this point, as well as that which finds its way down the glazing bars. If this moisture is considerable it can be released by cutting a chamfer on the inside top edge of the sail, widening the chamfer towards the middle, where a small hole can be bored to lead the water to the outside.

Where there is a sill that projects beyond the glazed lights, on the inside, a groove can be hollowed out and a small hole drilled, sloping downwards towards the outside. A small bore copper tube can be put into this hole, to prevent the escaping water from soaking into the surrounding wood.

CHAPTER 12

CONCRETE WORK

PORTLAND CEMENT. TENSILE STRENGTH. SETTING TIME. STORAGE OF CEMENT. SELECTION OF AGGREGATES. PROPORTIONING MATERIALS. GAUGE BOXES. MIXING THE MATERIALS. METHODS OF WATERPROOFING. SAFE STRENGTHS. REINFORCED CONCRETE. CONSTRUCTION OF LINTELS. CURING CONCRETE. RULES FOR FORMWORK. TYPES OF FINISHES.

CONCRETE is something more than just a mixture of stones, sand, cement and water. It is an important and versatile building material which can be used for an almost infinite variety of purposes. While plastic it can be moulded into practically any shape, and when set it possesses great strength and durability.

Concrete is employed extensively in foundations, site coverings, floors, retaining walls to basements, lintels, sills, thresholds and paving.

Specifications

Practically all Portland cement made by well-known manufacturers in this country is considerably above the requirements of British Standard Specification.

When ordering cement, it is desirable to ask for a works test sheet of the consignment of which the small order is a part. The cement manufacturer likes to see that the builder takes an interest in the specification requirements.

Proper storage of cement is an important matter, and when the consignment is delivered to the job or builder's yard, it must be kept in a dry, well-ventilated shed with the floor well off the ground to prevent damp reaching the cement. Even when the cement is properly stored, it should not be used after three months storing without a representative sample being sent for re-testing.

Slow-setting Portland cement is the commonly used builder's material. There is a quick-setting variety manufactured, but it is not used for building repairs unless it is required for under-water purposes.

There is yet another type of cement on the market: this is called rapid-hardening cement, and must not be confused with rapid-setting cement. It has the usual slow-setting properties, but the resultant concrete matures more quickly and gets as hard in a few days as concrete made with ordinary Portland cement does in twenty-eight days. This rapid-hardening cement costs more than the ordinary variety, but the time saved in completing a job may justify the extra outlay.

Aggregates

Sand and gravel are very good for ordinary concrete work, but any inert material of suitable size and free from impurities may be used as aggregates. Such materials as clinker, breeze, broken brick, stone chippings and slag are often used, but they are

likely to contain impurities, and should be avoided unless the situation of the job in hand is in a district where gravel and sand are unobtainable. Concrete made with broken brick or clinker, even if clean and free from impurities, is not as strong nor as waterproof as ballast concrete.

Whatever aggregate is used, however, the importance of clean materials cannot be too highly stressed. Some impurities have the effect of preventing the cement from setting and hardening. Others, such as clay or loam, by coating the particles of sand and pieces of stone with a thin film of clay, prevent the cement from coming into actual contact with the particles of sand and stone, and the resultant concrete is considerably weaker and disintegrates more readily.

Probably the best aggregate of all, for a very strong and durable concrete, is granite, but it is expensive, except in the districts where it is quarried. Sawdust and pumice are sometimes used to make a light-weight concrete, but these are special compounds and are not in general use.

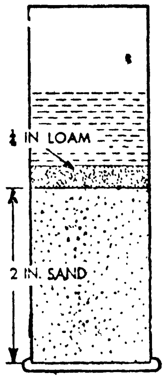


Fig. 1. Simple method of testing sand for cleanness.

Grading Materials

The size of the particles forming the aggregate must be carefully considered. Tests on concretes of various mixtures are often published, and quite apart from the quantities of sand, ballast, cement and water, which will be dealt with later, the grading plays an important part.

Concrete is usually made with ballast which will pass through a $\frac{3}{4}$-in. mesh down to $\frac{1}{4}$-in. mesh, and the sand of a size that will pass through a $\frac{1}{4}$-in. mesh. It is not clear from this description, however, that the ballast should be *graded* between what will pass through a $\frac{3}{4}$-in mesh and be retained on a $\frac{1}{4}$-in. mesh, nor is it clear that the sand must be *graded* from $\frac{1}{4}$-in. downwards. Unless this is made more definite, the foregoing description could apply to ballast of all the same size, say just under $\frac{3}{4}$ in., and to sand which is all dust and would make a poor and hungry concrete.

So much attention has been paid in recent years to concrete as a building material that the majority of sand and ballast merchants to-day have excellent screening and washing plants, and it is generally easy for the builder to obtain properly graded and well-washed materials. Grading is nearly always discernible by inspection, but the cleanness of the materials, particularly of the sand, should be verified by the following simple test.

Tip into a cylindrical glass vessel a quantity of the sand to be tested until the jar is half full. Add water until the jar is three-quarters full, and shake the mixture vigorously, and allow it to stand for one hour. After that time, measure the depth of the sand and of the loam or silt settled on the top of the sand. Calculate the amount of silt as a percentage, and if it is not more than 6 per cent, the sand can be considered clean enough for good concrete work. Such a test is shown in Fig. 1.

The depth of the loam is $\frac{1}{4}$ in., the depth of the sand 2 in. This makes a total depth of $2\frac{1}{4}$ in. and the percentage of loam is, therefore,

$$100 \times \frac{0.25}{2.25} = 11.1$$

which is too great, and the sand should be rejected or washed thoroughly. It is clear from this that in order to conform to the required standard of cleanliness the depth of loam or silt must not exceed $\frac{1}{8}$ in. on 2 in. of sand, after settling for one hour.

The importance of clean and well-graded materials, sand and ballast, and a good brand of cement, cannot be too strongly emphasised: the resultant concrete is well worth the trouble.

Proportion of Ingredients

In *proportioning materials* or ingredients there is often a tendency to be haphazard. It is true that almost any mixture of sand, ballast, cement and water will make concrete of a sort, but if the builder wants to be looked upon as a craftsman, he must *measure* the materials properly. What used to be called a 4 : 2 : 1 mix is now specified as follows:

Coarse aggregate (ballast)	5 cu. ft.
Fine aggregate (sand) .	$2\frac{1}{2}$,,
Portland cement . .	112 lb.

A gauge box should be of the correct size to measure one gauging at a time. It is true that it is easier to fill a barrow two or three times and guess half a barrow load, but when that is done, the builder does not know accurately what his proportions really are.

Now that cement is sold in 112 lb. bags, there is no difficulty with regard to its measurement, especially as the rule nowadays is to specify it by weight and not by volume. The amount of water to be added is also an important factor in the making of good concrete, and the builder is urged not to allow the concrete to be too wet.

Wet concrete is quite definitely not so strong nor as dense as "dry" concrete. The term "dry" needs a little qualification: there must be, of course, sufficient water added to complete the chemical action of the cement and to allow the concrete to be tamped and rammed into the moulds. A concrete with just sufficient water to permit this is called a dry concrete and should stand in a compact heap on the banker.

A concrete which flows under its own weight, rather like a soup or gruel, is too wet, and should be avoided. The stiff concrete requires more energy on the part of the concretor when placing it, but it is definitely stronger, and when well tamped it is more waterproof and more durable than wet concrete.

Slump

Some specifications state how much water should be used to a gauging, giving the quantity in gallons; but this is difficult to work to in practice, because the sand and ballast are usually delivered to the site containing an appreciable but unknown quantity of water. Furthermore, these materials are usually stored in heaps in the open, and consequently collect moisture.

It frequently happens, therefore, that the concrete comes out too wet, even though the correct quantity of water has been used. The stiffness, or consistency, of concrete is often ascertained by a slump test, and the engineer in

that case would specify a slump of a certain number of inches. For full details of how to carry out the slump test the reader is referred to Appendix VI of the Code of Practice for Reinforced Concrete, published by H.M. Stationery Office.

Mixing Materials

Mixing the materials is an important part of the task of making good concrete, and the ideal is a good batch mixer—driven by an electric motor, or petrol or paraffin engine. It is probable, however, that the requirements of concrete for building repairs will not warrant the installation of a mechanical mixer. It is most likely that the requirements will be for small quantities of concrete on a large number of sites, and this is sure to mean hand-mixed concrete.

Most engineers specify that when concrete is mixed by hand 10 per cent extra cement should be added; in other words, if the amount of cement specified for a gauging is 112 lb., an extra 11 lb. must be added for hand-mixed concrete. In the absence of a specification, the builder must exercise his discretion in this matter. It will depend on the work the concrete has to do. For instance, we should recommend the additional cement to be added when making reinforced concrete lintels, or a retaining wall or a water tank, but it would hardly be justified in the case of a repair to a garden path or a doorstep.

For hand-mixed concrete, the measured ballast and sand are placed on the banker or mixing site. The gauge box can be made to contain the required quantity of ballast in one filling with a line of metal strip at the half-way mark. It is then filled to the top with ballast, and as far as the metal line for the sand.

Another method is to make the box, without a bottom, of course, just large enough for the sand, and to fill it once for the sand and twice for the ballast. Yet a third method is that in which the gauge box is made of a size just sufficient to hold *all* the sand and ballast. A line of metal-strip is placed on the inside two-thirds the way up, and the box is filled to the line with ballast, and the top third is filled with sand. Fig. 2 shows a usual form of gauge box.

If the measure is placed on the banker and filled with the requisite quantity of material, the aggregates are ready for the cement to be laid on top of them when the box is lifted off by means of the handles.

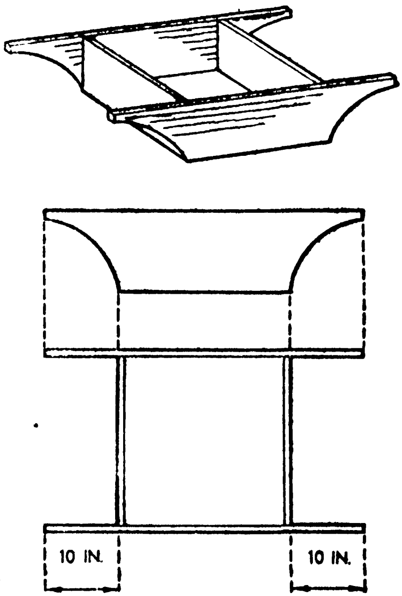


Fig. 2. Common type of bottomless gauge box which is usually employed for measuring aggregates.

Before any water is added, the ballast, sand and cement in their dry state should be thoroughly mixed together and should be turned completely over at least three times. Then the water is added through a rose and the process of turning over is continued until the whole batch is well mixed and of the right consistency. As the chemical action of the cement commences immediately it becomes wet, it is important that the concrete is placed in the moulds, or where it is required, with as little delay as possible.

Particular care should be exercised to avoid such a situation arising as a batch of mixed concrete being left on the bunker while the men "knock off" for dinner.

Ready-mixed Concrete

Ready-mixed concrete is something new in the field of concrete work. This has much to be said in its favour, particularly where the concrete is required to be delivered to confined sites where there is insufficient space for working and for the storage of cement, sand and ballast. The contractors who supply the ready-mixed concrete undertake to work to any specification required, and their method of working usually includes a mechanical mixer fastened on a lorry.

On leaving the yard, the requisite amounts of cement, sand and ballast are put into the drum of the mixer and the correct amount of water for this quantity of material is put into a separate tank.

As the lorry travels on its journey to the site, the drum rotates continuously, thus thoroughly mixing the dry materials. When the lorry-cum-mixer is within a quarter of an hour's journey from the site where the concrete is required, the driver turns a valve and lets the water flow from the tank into the drum. When the mixer arrives on the job, it delivers a quantity of well-mixed concrete ready for use.

Although the strength of cement is usually denoted by its strength in tension, that of concrete is usually in terms of its crushing strength—*i.e.*, the stress per sq. in. under direct compression. A cube of concrete, 6 in. each side, is made in a steel or iron mould: Appendix VIII of the Code of Practice gives a detailed account of the making of works cube tests, and reference to that excellent description is recommended.

At the age of twenty-eight days the cube is placed in a testing machine and compressed until failure occurs. The total force producing failure, divided by the area of the concrete being crushed (36 sq. in. in the case of a 6 in. cube), gives the crushing strength in lb. per sq. in. Ballast concrete of the proportions given above should give a crushing strength of not less than 2250 lb. per sq. in. in twenty-eight days and Table I (page 274) shows the minimum strengths at twenty-eight days for several other mixtures—*i.e.*, different proportions of ballast, sand and cement.

Waterproofing Concrete

The waterproofing of concrete presents problems of a varying nature, because there are many preparations on the market which claim to make concrete waterproof. Some are powders to be added to the cement in a dry form before mixing; some are liquids to be added to the mixing

Mix Ref. No.	Nominal mix.	Proportions, cu. ft. of aggregate per 112 lb. of cement.		Minimum crushing strength at 28 days, lb. per sq. in.	Permissible working stresses, lb. per sq. in.	
		Fine (sand).	Coarse.		Direct compression.	Shear.
1	1 : 1 : 2	$1\frac{1}{4}$	$2\frac{1}{2}$	2925	780	98
2	1 : 1·2 : 2·4	$1\frac{1}{2}$	3	2775	740	93
3	1 : 1·3 : 2·6	$1\frac{2}{3}$	$3\frac{1}{3}$	2670	712	89
4	1 : 1·5 : 3	$1\frac{7}{8}$	$3\frac{3}{4}$	2550	680	85
5	1 : 1·75 : 3·5	$2\frac{1}{4}$	$4\frac{1}{2}$	2400	640	80
6	1 : 2 : 4	$2\frac{1}{2}$	5	2250	600	75

Table I. Details of the minimum crushing strengths and safe loads for various concrete mixes after a period of 28 days.

water; and there are others in the form of a surface application.

It is a fact, however, that good concrete, well tamped and rammed so as to exclude air holes and to make the concrete as dense as possible, is of itself waterproof; and in the case of leaky water tanks and retaining walls the trouble frequently arises from two sources: construction joints, and shrinkage and settlement cracks.

Construction Joints

The term 'construction joints' means the break between one day's concrete and the next. Trouble here can be reduced to a minimum by making all joints rebated, and by chipping off the hard surface of the previous day's concrete and placing thereon about 1 in. of 3 to 1 cement-mortar before placing the new concrete.

With regard to cracks due to settlement, it must be clear that even if the concrete is waterproof in itself, or if it has been made waterproof by one of the preparations referred to, a wall, raft or tank will leak if a crack appears in it. Probably the best way to guard against a leaky wall, if the soil on which it is founded makes settlements suspect, is to use asphalt or bituminous sheeting between the earth and wall, during building operations.

Reinforced Concrete

If a settlement or a shrinkage crack appears in an existing concrete wall, it is too late to asphalt the back of it, or to put bituminous sheeting there. The best remedy is to cut out the crack, clean the surface thoroughly and fill with a 3 to 1 cement-mortar. If, however, water is seeping through the crack, a very quick-setting cement is required and the filling of the crack must be done very quickly, gauging only small quantities of the mortar at a time; any quantity more than can be used with a trowel in one operation will set hard while that on the trowel is being applied.

If the leak is a bad one, a specialist firm should be consulted. Firms of repute will give a guarantee of watertightness, and the builder and his client will be safeguarded if one of these is employed.

Reinforced concrete is a structural material rather than a building material, comparing with structural steelwork in its applica-

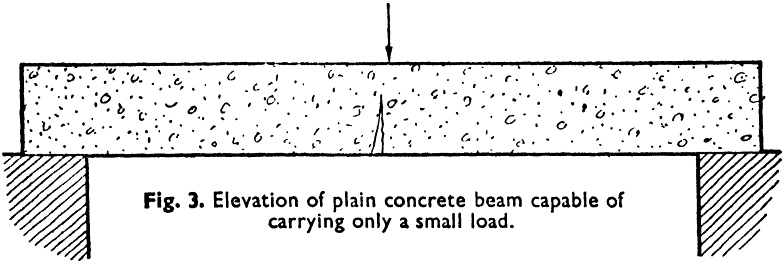


Fig. 3. Elevation of plain concrete beam capable of carrying only a small load.

tion, but it is desirable for the builder to know something about it. Plain concrete, while it is strong in compression, is weak in tension. If, therefore, in a structural member steel bars are placed in a position where tension occurs, the member will carry a much greater load than if the member were made of plain concrete.

Safe Tension

Consider a plain concrete beam as shown in Fig. 3 carrying a load at mid-span. Using a concrete of the mixture already referred to, having a safe tension stress of 75 lb. per sq. in., it would carry only a small load, say 600 lb. at the centre. If this load were increased until failure occurred, the concrete would crack and the beam would open at the bottom at or near the centre, as indicated in the diagram.

If the tension at the bottom of the beam is taken up by steel rods, properly designed and placed, instead of by the concrete, the beam would safely carry about 6000 lb.—*i.e.*, about ten times as much. Fig. 4 shows a similar concrete beam with the reinforcement required to achieve this result.

The correct amount of steel and the position of it are the result of very careful and scientific calculations, and the builder is recommended to leave that part of it to the structural engineer. If, however, the builder understands why the steel rods are so placed, he will be better able to execute the work shown on the engineers' drawings. In slabs and beams which are constructed continuously over several supports, the tension occurs in the bottom at mid-span, but in the top at the supporting beams or walls, as illustrated in Fig. 5. As shown in Fig. 4 the diagonal rods at the ends of the beams and stirrups are to resist shear forces.

Lintels are a very necessary and common part of builders' work,

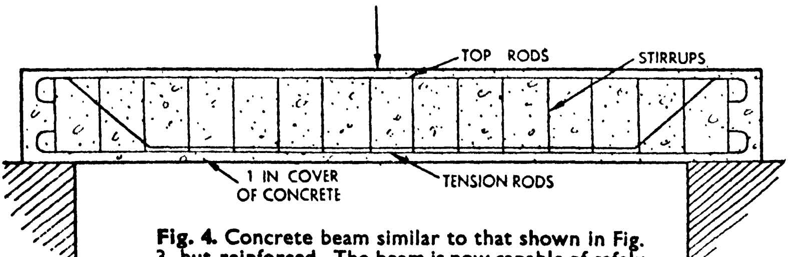


Fig. 4. Concrete beam similar to that shown in Fig. 3, but reinforced. The beam is now capable of safely carrying a load of 6000-lb. at mid-span.

and these are usefully constructed in reinforced concrete. Sometimes lintels are cast *in situ* and sometimes they are cast in moulds on the ground and hoisted into position when they are sufficiently matured. Table II gives the sizes and reinforcement for various spans. The rods should have their ends hooked, and must be placed in the bottom of the lintel with not less than ½ in. cover of concrete underneath and 1 in. cover at the side. Care must be taken to put the correct number of rods to suit the wall thickness, even though the width of the lintel itself is reduced to allow for the facing.

Pre-cast lintels work out cheaper than those cast *in situ*, chiefly because the moulds can be made cheaply and can be used many times. When erecting them, however, they must be set the right way up, with the rods at the bottom. Pre-cast concrete can be extended to many departments of repairs, such as concrete steps, paving stones, and sections of reinforced concrete for floor slabs.

Curing or maturing is a necessary part of the process of making good concrete. It is true that concrete will set and go hard if left alone, but if the action is assisted, the resultant concrete is harder and denser. In cold weather frost must be kept out of the concrete. In hot weather the direct rays of the sun must be kept off the concrete, and it should be kept moist by covering with wet sacking. As soon as the concrete is a day old it should be kept wet for at least a fortnight. Watering with a hose two or three times a day is generally sufficient, but if the sun is very hot and dries the water quickly, the surface of the concrete should be watered more often. These precautions are simple but important.

Shuttering

Formwork or shuttering is generally left to the carpenter, but a few simple rules must be kept in mind:

The formwork must be so planned that it can be removed or "struck" easily without loss of timber.

It must be so designed that it can be used several times.

Formwork for a floor must be capable of supporting its own weight, plus the weight of the wet concrete and plus the weight of men and barrows, without appreciable deflection.

Formwork for walls or columns must be so secured with cramps and/or struts that the weight of concrete does not cause it to bulge.

Formwork should be cleaned thoroughly before re-using.

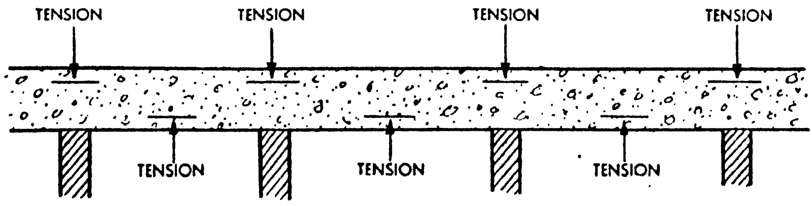


Fig. 5. Concrete beam extended over several supports. The points of tension are indicated but the lines are not intended to denote the extent of the tension forces but only to show whether they are in the top or the bottom.

Clear span.	Depth of concrete.	Rods required for wall thickness.			
		9 in.	13½ in.	18 in.	1 ft. 10½ in.
ft. in.	in.				
3 0	6	2—½ in.	3—½ in.	4—½ in.	5—½ in.
4 0	6	2—½ in.	3—½ in.	4—½ in.	5—½ in.
5 0	9	2—½ in.	3—½ in.	4—½ in.	5—½ in.
6 0	9	2—½ in.	3—½ in.	4—½ in.	5—½ in.

Table II. Reinforced concrete lintels. Details of the reinforcement required for various spans and the number of rods for different wall thicknesses.

Concrete finishes can be dealt with under two headings: applied finishes made of concrete, and finishes or surfaces required of the concrete itself.

Concrete Finishes

Of the finishes made of concrete the following may be mentioned: granolithic—granite concrete laid on ordinary concrete where hard wear is to be expected; pre-cast concrete slabs for paving, cement rendering and such like, although the latter probably comes in the work of the plasterer.

Granolithic, generally about 1½ in. thick, should be laid while the base concrete is green, but if repairs are to be done and the base concrete exists, it must be given a good key. All grease and dirt must be removed and the old surface hacked before laying the granolithic.

For a hard-wearing surface to withstand heavy vehicular traffic the following mixture is recommended, 3 in. of granite-concrete; granite chippings (¾ to ¼ in.), 4 cub. ft.; sand (¼ in. down) 2 cub. ft.; cement, 112 lb. It should be laid on a 6 in. concrete slab before the initial set has commenced and rodded into it.

Pre-cast slabs for paving can be laid on ashes or sand, or on a ½ in. of cement-mortar on a concrete slab, according to the traffic it is likely to receive.

Granolithic and cement rendering must not be too wet or too rich in cement, or shrinkage cracks will appear.

When the concrete provides its own surface or finish, the treatment will depend on what is specified or required. A smooth finish can be achieved by using tongued and grooved boards for the shuttering, wrought on the side next the concrete. Steel shuttering also gives a smooth finish, as does plywood fastened to the inside of the formwork. When placing the concrete, it must be well tamped and rammed, working the cement paste against the formwork, and when the latter is removed, a rubbing with a carborundum brick will remove unavoidable unevenness.

Special Surfaces

Other surfaces, such as exposing the ballast and grinding and polishing it, using coloured aggregates and sands to imitate various natural stones, are highly specialised, and the advice and help of specialist firms should be sought.

Here is another rule to be followed when applying new concrete to old. Suppose the top of

a concrete wall has been broken off and it is desired to restore it to its original height by adding new concrete. Before erecting the shuttering, chip off about an inch of the old hard concrete and after the shuttering is in position, place about one inch of 3 : 1 cement mortar on the surface of the old concrete, which must be made wet. Before this layer of mortar has set, place the new concrete. The cement mortar forms a cushion for the aggregate to bed into and avoids air pockets. Concrete must always be well rammed and punned to ensure a dense concrete free from air holes.

The foregoing has been written to give the builder a useful knowledge of concrete as a building material, a material which can be used in many places for repairing damaged building work. Concrete is itself a valuable repair material.

Cracks in Concrete

When it comes to repairs in concrete, however, the builder must proceed carefully. The uses to which concrete is put in the making of a building are so various that one cannot give a general rule; one must consider each case on its merits. Sometimes a crack in concrete will not matter very much, but it can be a sign of a structural failure.

Generally speaking, cracks in concrete will always show. They should be dealt with by cutting away the concrete from each side of the crack (called cutting out the crack), making the crack in effect wider. This gives the builder working space in which to insert some cement mortar gauged 3 parts sand to one part cement. Before filling, the space must be cleaned thoroughly and made well wet with water. The mortar, which must not be made too wet, will be applied with a trowel, working up from the bottom if crack is vertical.

If a diagonal crack has appeared in a concrete wall, it will probably mean that a settlement has occurred and the builder will be well advised to seek the services of a civil engineer. Filling the crack as described above will not be a cure for the settlement.

Foundation Repairs

Foundation concrete which has suffered damage must be examined very carefully before any repair is attempted. The foundation may be carrying a heavy load and the stress on the soil will be increased if the effective area of spread is reduced. If the foundation concrete under a brick wall has been broken, patching with new concrete will not effect any improvement. If the fracture is of such a nature that the full width of concrete spread cannot act in one piece, the only cure is to underpin in short widths (not exceeding 4 ft. 0 in.) and to place new concrete under the brick footings, after removing the damaged concrete, for the full width of the original concrete.

If a stone or concrete step has cracked through, it must first be examined to ascertain if it is spanning between walls or other supports as a beam. If it cannot be removed and replaced, it will have to receive support underneath, and such support could be given by a reinforced concrete beam. The top of the supporting beam should be kept about 2 in. below the underside of the cracked step and, when the new concrete is a day or two old, this space should be filled by ramming into it 3 : 1 cement mortar, mixed fairly dry.

CHAPTER 13

SPECIFICATIONS AND COSTING

OBJECTS OF SPECIFICATIONS. INSPECTION OF PROPERTY. METHODS OF PREPARING SPECIFICATIONS. DESCRIPTION OF WORK. TRADE DIVISIONS. SURVEYING PROPERTIES AND BUILDING SITES. ORDNANCE BENCH MARKS. PROBLEMS OF COSTING. ESTIMATING FROM SKETCH PLAN. CUBING. BILLS OF QUANTITIES. SCHEDULES OF DILAPIDATIONS. WEAR AND TEAR.

ONE of the first things which anyone engaged on building repairs comes in contact with is the necessity of describing the quality of material to be used and the class of workmanship to be executed. In other words, some knowledge of how to write specifications becomes of great importance. This is necessary for three reasons: firstly, to guarantee the client a defined standard; secondly, to instruct the various tradesmen on the methods which are to be adopted in carrying out the work undertaken; and thirdly, to define clearly the contractor's responsibilities.

Method of Approach

Having described why specifications must be written, the problem of how they must be written arises. The best way to tackle this is, perhaps, from the point of view of a tradesman who, starting a one-man business of decorating, has developed into a small-scale building contractor.

Probably the first job will be a request to give an estimate for re-distempering a ceiling. As an estimate cannot be submitted without a description being given of the work and materials covered by the price stated, a start on writing specifications at once becomes necessary in order to achieve this end.

Definition of Requirements

The first point to remember is that it is unlikely that the client has any knowledge of decorating, and, therefore, cannot be expected to define his true requirements. For instance, although a client requests a price for "re-distempering a ceiling", if the successful tenderer took him at his word and applied a coat of distemper without any preparation, he would most likely be out of business in a very short time.

To make this point quite clear it will be assumed that a price for this work is being submitted by the decorator in competition with three other firms, all of which are carrying out work of an equal standard. The estimates would arrive something like the following:

Estimate (1). To re-distempering ceiling of kitchen, two coats . . . for the sum of £ . . .

Estimate (2). To wash off and distemper ceiling of kitchen, two coats . . . for the sum of £ . . .

Estimate (3). To wash off, clairecolle, and distemper ceiling of kitchen, two coats, for the sum of £ . . .

Estimate (4). To wash off, cut out cracks, stop, clairecolle, and twice distemper ceiling of kitchen, for the sum of £ . . .

Now, all the firms concerned would, it can be assumed, carry out the preparatory work as a matter of course, knowing that the client would expect the finished work to be without flaw, although not rigidly defining his requirements in giving instructions; but it is fairly certain that, prices being near equal, the client would accept Estimate No. 4, on the grounds that careful thought had been used in correctly anticipating his wishes.

Having explained the principles on which specifications should be based, a description will now be given of the complete re-decorating of a single room:

Walls. Strip paper, cut out cracks, stop, size and hang new paper P.C. 4*s*. per roll and border P.C. 1*s*. per yard.

(Note. The initials P.C. mean prime cost—that is, a sum included in an estimate to cover an item, or items, generally selected by the client. If the cost of the client's choice is lower or higher than the P.C. sum, or sums included, the estimate is decreased or increased in relation to the actual cost. P.C. sums should clearly indicate whether they refer to a sum included to cover a number of items or to each item individually, hence the wording "per roll" and "per yard".)

Ceiling. Wash off, cut out cracks, stop, clairecolle, and twice whiten.

(Note. Claircolle is a mixture of whiting, size and alum applied to prevent the dry plaster sucking the water content from the distemper too quickly, and thus causing flaking. Where ceilings are badly scarred through previous badly carried out stoppings, a lining paper is sometimes used as a base for the distemper, and this clause would then read: ". . . stop, size, line with stout lining paper, and twice whiten.)

Paintwork. Rub down, bring forward, and paint two flat undercoats and one full gloss finishing coat with white lead oil paint to selected colour.

(Note. The term "bring forward" is to cover additional coats applied to badly worn places or broken blisters to bring these up to a body and surface equal to the surrounding work.)

Now let us take a large step forward and take as an example a small property in very bad repair which a landlord requires to be repaired, modernised and decorated before re-letting. We will assume that it is a house comprising living-room, kitchen, two bedrooms and a bathroom, main constructional details being brick walls, slated roof, sash windows and out-of-date grates and sanitary fittings.

Division of Trades

As several trades will be involved in the carrying out of this work, the question arises whether the specification shall be divided into trades, or whether work to be done in each room shall be described separately, irrespective of trades. Opinions differ regarding this, but it is perhaps better to adopt the latter method for work which can be rightly described as repairs or decorations to property, and reserve the former method for new additions to, and erection of, properties.

Having decided upon this course, the client's instructions should be examined. Assume they read as follows:

Iron grates and mantelpieces to be replaced by open grates and tile surrounds throughout.

Kitchen range to be replaced by small "open-fire"-type of domestic boiler.

All sanitary fittings to be renewed, but connected to existing services.

Locks to be renewed throughout.

Roofs and windows to be overhauled.

New cupboard required in back bedroom. Glazed doors to be fitted to top portion of kitchen dresser. Picture-rail required in living-room.

Redecorate throughout over existing decorations where possible. Amount to be expended approximately £125.

Inspection of Property

On receipt of these instructions the property must be inspected and notes taken to form a basis of the specification. These should be noted roughly in the same sequence as proposed for the specification, as follows:

Living-Room. Iron register, remove; plaster will require making out. Stone hearth, take up; concrete for tiles.

Window, two sash-cords broken, upper R.H. pane cracked.

Walls, papered, bad condition, strip.

Ceiling, very discoloured and cracked, line before distempering.

Woodwork, dark brown paint and varnished, burn off.

Kitchen. Double oven iron range in opening 4 ft. wide × 5 ft. high × 1 ft. 10½ in. deep. Stone slab surround and shelf.

Stone hearth, full width of opening × 2 ft. wide: take up and concrete for quarries.

Stone sink on brick piers, draining board badly worn.

Window catch and two lower panes of glass broken.

Dresser top, 1 in. sides and bottom, three intermediate shelves: size to cover 3 ft. 6 in. wide × 3 ft. 9 in. high.

Walls, painted cream, fairly good: use as base for two-coat work.

Ceilings, discoloured, but no cracks.

Woodwork, light green paint, fair condition.

Hall. Bolts to door: rusted, renew, 8 in.

Staircase, square vertical balustrade (three broken), closed outer string and capping mould: close with ply and cover beads both sides.

Walls, buff distemper (washable), very dirty.

Ceiling, cream colour wash, fairly good, no cracks.

Woodwork, dark brown paint, flat finish: burn off.

Front Bedroom. Iron register: renew.

Stone hearth: take up, size 3 × 1 ft.

Window: renew two sash lines.

Walls, plain light buff paper, good condition: distemper over.

Ceiling, distemper, bad cracks.

Woodwork, light brown gloss paint, bad: burn off.

Back Bedroom. Register and hearth as front bedroom.

Window, sash lines good.

Walls, colour washed, dark buff: wash off.

Ceiling, colour washed light buff, good.

Woodwork, stained and varnished: rub down and varnish one coat.

Bathroom. Fittings, W.C. basin and bath, lead tray under bath: remove complete.

Window, one pane cracked (small cathedral roll), sash lines, good.

Walls, wood dado 4 ft. 6 in. high: paper above strip.

Ceiling, distemper, bad cracks, sagging in corner next party wall, 2 × 2 ft. take down.

Woodwork, dark brown paint and varnish: burn off.

Landing. Decorations as hall.

Externally. Woodwork, faded and badly blistered: burn off complete.

Ironwork ditto.

Porch, stone flags, worn, lay quarries.

General Items: Locks. Mortise locks throughout except cylinder night latch to front door: renew except latch.

Electric Wiring. Recently wired, one ceiling point in each room, lighting plug point in living-room,

power-plug point in living-room and kitchen, Bakelite terminals and plugs, good.

Gas. Service to cooker point in kitchen only.

C.W. Services. All lead, appear in order.

H.W. Services. In iron, ditto.

Tanks. C.W. in roof, holed: renew. H.W. in kitchen, sound.

Roof. Slates, 16 × 10 in. thin greys, approx. 5 per cent broken or displaced. Cement fillet only to stacks, breaking away: provide soakers, flashing and apron.

Drains. Hold up under water test.

With this information a start should be made on the specification while the particulars are still in mind.

SPECIFICATION of work to be executed and materials to be used in the repair, modernisation, and decorating of . . .

Living Room. Take out iron mantel register, interior, fret and firebricks complete and remove. Provide the P.C. sum of £6 10*s*. for new chimney-piece, including wood surround interior, slabbed tile cheeks and kerb and loose tiles for hearth to be selected from an approved manufacturer, set complete; build in with concrete, fireclay, including cheeks; plug for and screw-fix wood surround and make good to wall plaster all round.

Hack up stone hearth, break down for hardcore, add to as required, blind with ashes and lay 3 in. thick, Portland cement concrete of 1 : 2 : 5 mix; screed for and lay hearth tiles supplied with chimney-piece and fix slabbed kerb ditto.

Carefully remove window architrave and linings to side windows, take out sashes, renew sash lines with best flax cords in No. 2 and refix complete.

Take out cracked upper pane of right-hand window, and re-glaze with glass of equal weight and quality, sprig, putty and back putty.

Plug walls all round at height of 7 ft. and provide and fix 2½ × 2 in. grooved and splayed deal picture rail.

Strip papered walls; clean down, cut out cracks, stop, size and hang new paper to be selected P.C. 3*s*. 6*d*. per roll and border P.C. 9*d*. per yard.

Wash off ceiling, cut out cracks, stop, size, line with stout lining paper, including new frieze, and twice colour wash, cream.

Burn off painted work to bare wood and knot, stop, prime and paint two flat undercoats and one eggshell finishing coat, dark cream.

Kitchen. Take out double oven range complete with iron flue pipe, disconnect flow and return to back boiler, and remove all complete.

Ditto stone surround and shelf and ditto.

Rake out brickwork joints for key all round and full height of opening and returning 6 in. on jambs and head; render in cement and sand, 1 : 3 mix, and line with first-quality 6 × 6 in. white glazed tiles; finish on free edges with bull-nosed tiles, point in white cement, and make out and make good to plaster all round.

Hack for key to stone-flagged hearth, and screed for and lay 9 × 9 × 1 in. red quarry tiles and finish on free edges with 2 × 1 in. hardwood splayed fillet.

Provide and fix "open-fire" type domestic boiler of approved make, minimum capacity 25,000 B.T.U.'s per hour, complete with safety valve, thermometer, glazed stove pipe and firing tools. Pick up existing primary flow and return, extend as required in red steam quality steam tubing of similar bore and connect to new boiler.

Disconnect stone sink and trap complete and remove.

Take down brick piers to below floor level, remove and make out floor boarding as required.

Provide new 24 × 18 × 10 in. white glazed sink complete with chromium-plated chain and rubber plug, enamelled cast-iron cantilever brackets and lead trap. Plug walls for brackets and fix all complete and connect to existing waste.

Take off existing bib-cocks and remove, adjust services to suit new sink and provide and fix new chromium-plate bib-cocks, appropriately labelled.

Provide new glazed doors to upper part of dresser, hung folding

in No. 1 pair on face of existing framed shelving with ½ in. cover all round. Doors to be framed with 2½ × 1½ in. stiles, heads and rails, and No. 3 1½ × 1½ in. vertical glazing bars to conceal shelving, all rebated and with loose beads for glazing. Glaze with 18-oz. O.Q. brand clear sheet, hang on 3 in. pressed steel butts and secure with 2 in. flush pattern brass cupboard lock, plastic knob and No. 2 4 in. brass neck bolts.

Provide and fix 8 in. iron barrel bolt and staple to back entrance door.

Take off broken catch to window and renew.

Take out broken lower panes to window in No. 2 and re-glaze with large cathedral roll obscured glass, sprig, putty and back putty.

Rub down walls, bring forward where made good, and paint one flat undercoat and one matt finishing coat, dark cream.

Wash off ceiling, prime and paint two flat undercoats and one flat finishing coat, cream.

Rub down woodwork and paint one flat undercoat and one full gloss finishing coat, sea green, except new doors, knot, stop, prime and paint two under and one finishing ditto.

Hall and Landing. Take off bolts to front entrance door in No. 2, remove and provide and fix 8 square brass spring bolts and staples, secured with screws to match. Take out broken balusters to staircase in No. 3, replace with 2 × 1 in. studs and line balusters either side with ¼ in. thick, birch faced three-ply secured with screws to each baluster immediately below handrail and above capping; and fix cover beads all round either side.

Wash down walls and distemper two coats with oil-bound water paint, buff.

Wash off ceilings, clairecolle, and twice colour wash, cream.

Burn off painted work to bare wood, twice stain light brown and finish with one coat clear copal varnish.

Rub down and re-polish handrail.

Front Bedroom. Take out iron mantel register, interior, fret and firebricks complete and remove. Provide the P.C. sum of £4 10*s*. for slabbed tile surround, hearth and interior, to be selected, and set surround and interior complete; build in with concrete and fireclay, plug for and screw fix lugs, and make good plaster all round.

Hack stone flagged hearth for key, screed to flush with flooring, set slabbed tile hearth and fix ½ in. cover bead all round.

Take out sashes, renew No. 2 sash lines and refix as described for living-room.

Twice distemper walls over existing paper with oil-bound water paint, primrose.

Wash off ceiling, cut out cracks, stop, clairecolle and twice colour wash, cream.

Burn off painted work to bare wood, knot, stop, prime and paint two flat undercoats and one full gloss finishing coat, primrose yellow.

Back Bedroom. Take out register, remove and provide and fix new tile surround and hearth all as described for front bedroom, P.C. £4.

Frame up new cupboard between breast and internal wall, full width and height of recess by 1 ft. 3 in. deep inside with 1 in. thick front and returned end; ditto false bottom at skirting level and intermediate shelf, 6 ft. off floor, rebated to flush with outside face; and frame double doors, hung folding in two heights, with 3 × 1 in. square framing and ¼ in. thick double birch faced three-ply panel infilling; hang on 3 in. pressed steel butts and secure with 2 in. flush brass cupboard locks, plastic knobs and 4 in. brass neck bolts, top and bottom. Make out skirting to match all round, fix 2 × 1½ in. ceiling mould; ditto and ditto ½ in. cover beads, full height, either side.

Take out sash and renew No. 1 cord and refix as described for living-room.

Wash off walls and re-distemper two coats with oil-bound water paint, buff.

Once colour wash ceiling, light buff.

Rub down varnished woodwork and re-varnish one coat clear copal. Twice stain and once varnish new cupboard to match existing work.

Bathroom. Carefully disconnect and take out W.C. pedestal timber enclosure, lead lined timber cistern, and lead flush-pipe; remove com-

plete, give credit for lead, and provide new W.C. suite comprising white glazed pedestal with "P" trap, cone connector, black plastic seat with cover and chromium pillar hinges, porcelain enamelled cast iron cistern and ditto brackets, stainless steel telescopic flush pipe, chromium chain with rubber pull; fix complete and connect to existing soil branch.

Ditto basin complete with brackets and taps; remove and provide new 22 × 16 in. white glazed basin with chromium pillar valves and chain, rubber waste plug, and porcelain enamelled cast iron cantilever brackets; plug for and fix complete and connect to existing services and trap.

Ditto bath complete and including lead tray and floor fillets under; remove and give credit for lead, seal outlet to tray, make good flooring as required and provide new 6 ft. overall porcelain enamelled cast iron bath, complete with taps, chain and plug as for basin, and with black glazed asbestos cement riser. Frame for riser with 2 × 1 in. rough studs, fix all complete and connect to existing services and trap.

Take down wood dado and battens all round, rake out brickwork for key; render in cement and sand 1 : 3 mix and line with first-quality glazed tiles, bottom and top courses black, remainder white and finish on all free edges with bull-nosed tiles.

Strip papered walls above dado, rub down, cut out cracks, stop, and paint two flat under coats and one eggshell finishing coat, ivory.

Take down plastered ceiling and laths complete and remove. Line joists with ⅜ in. plasterboard, nailed to every joist and fixed to break joint; scrim joints, skim with coat of gypsum plaster minimum ⅛ in. thick, and paint one priming coat, two flat under coats and one flat finishing coat, broken white.

Burn off painted woodwork and knot, stop, prime and paint two undercoats and one full gloss finishing coat, cream.

Externally. Hack stone flags to porch for key, and screed for and lay 6 × 6 in. black paving tiles finished on edge with bull-noses and vertical tile riser under, and point in cement.

Burn off all painted work to bare wood; knot, stop, prime and paint two flat undercoats and one flat finishing coat, black to window and door frames and cream to sashes and panel infilling.

Scrape and scale ironwork and paint two coats bitumastic paint.

Roofs. Strip slating next stack, provide and fix 4 lb. lead soakers and stepped flashings and 6 lb. lead apron, all laps over and under slating to be minimum 6 in., and replace slates removed.

Carefully overhaul roof generally, replace all broken, cracked or missing slates to match and leave watertight.

General Items: Locks. Take off locks and furniture complete to all doors, except front entrance, and remove, fill up lock rebates and holes with wood strips and mastic; bring forward new wood as required for decorations and provide and fix iron rim latches with plastic furniture to all rooms except back entrance; ditto and fix iron rim lock and round iron furniture.

Tanks. Disconnect cold water storage tank in roof space, take out and remove. Provide new galvanised mild steel, welded tank of equal gauge and capacity, and connect up.

Flues. All flues to be thoroughly swept before decorations are commenced.

Miscellaneous Decorating Items. Cold water services where exposed to be painted in with room decorations.

Hot water services, where exposed, including hot water tank and brackets in kitchen, to be painted two coats aluminium paint.

Window fasteners and pulls and similar small fittings to be Berlin blacked.

Paints for external use to be genuine English white lead oil paints unless otherwise specified; for internal work to be ditto or zinc oxide oil paint.

Contingency Sum. Allow the sum of £20 for contingencies to be deducted in full or in part if not expended.

Test Services. Test water services, make good defects, and leave perfect.

Completion. Remove all rubbish, wash down floors and pavings, clean

glazing inside and out, remove all paint and plaster stains and leave the premises clean and habitable.

The foregoing specification has purposely been written on very simple lines and should be easily understandable from a descriptive point of view; but there is an alternative method of writing which deserves mention, namely to divide the work into two parts as follows: (1) Taking Down and Clearing Away and (2) New Work. This requires more care than the method adopted but has the advantage of giving both to the client and the tradesmen employed a clearer picture and easier grasp of the work involved. For practice in specification writing it is suggested that an attempt be made to re-write the specimen specification on the lines of this alternative method.

Extensions

We now give a description of the work and materials involved in the erection of new buildings. Perhaps the most straightforward example that can be taken is the building of a detached garage on a level, unobstructed site. The client's requirements will probably be "a garage to match the house and large enough for my car; cost to be kept as low as possible". The house is constructed with brick and multi-coloured concrete tiles, walls roughcast and pebble-dashed.

This work will require specifying under the various trade headings and the first step, therefore, is to jot these down with a synopsis of the work to be covered by the different trades:

***Excavator*. Remove hedge for new drive in; strip for surface concrete; trench for foundations, drains and water.**

Concretor. Foundations and concrete raft.

Bricklayer. 4½ in. walling, 9 in. piers. Metal window.

Drainlayer. Drains to existing soakaway; gulley to wash down.

Roofer. Concrete nibbed tiles to match house.

Carpenter and Joiner. Roof carcassing, plates and battens.

Bressumer over doors (no lintel required over window).

Door frames and doors, gates and posts. Fascia and soffit. Ceiling lining. Ironmongery.

Plumber and Smith. R.W. gutter and down pipe.

Stand pipe from existing service by house.

Glazier. Window and upper door panels.

Painter. Wood and iron work.

With this as a basis the specification can be built up:

SPECIFICATION of materials to be used and work to be executed in the erection of a detached Garage at . . .

Excavator. Grub up and take down hedge on road frontage, 8 ft. wide, in position of new drive in and remove.

Carefully cut and take up turfs, roll and lay aside for re-bedding.

Strip topsoil over site of new garage, wash-down and drive in to a depth of 9 in. and deposit and spread soil as directed.

Excavate for foundations 15 in. wide, down to natural bottom; part fill in and ram and deposit and spread surplus, as directed.

Ditto for surface water drains, minimum 18 in. deep, from feet of R.W.P. and gulley position to existing soakaway near house and ditto.

Ditto for water supply, minimum 18 in. deep, from existing stand pipe on flank wall of house to position next new garage doors and ditto.

Concretor. Lay over site of garage, wash down and drive in, hardcore composed of crushed stone, broken bricks or gravel to a thickness, after consolidation, of 4 in.

Fill in trenches to foundations with 1 : 3 : 6 mix, Portland cement

concrete, maximum 2 in. aggregate, 15 in. wide × 9 in. deep, and level off.

Lay over hardcore, 4 in. thick, 1 : 2 : 4 mix ditto concrete paving maximum ¾ in. aggregate, wash down dished to centre gulley, and all spade finished.

Bricklayer. Bricks—to be approved local commons, or flettons, grooved where rendered.

Mortar—to be composed of one part cement to three parts sand.

Build walls 9 in. thick off foundations to underside of concrete paving; set back from internal face and continue in 4½ in. work with 13½ × 9 in. centre and corner piers, to height of 7 ft. 6 in. off paving; leave openings for doors and window, flush joint internally and rake out joints for key externally, and do all necessary rough and fair cutting, beam filling etc., and bed plates and frames.

Lay over walls all round, 1 in. below surface of concrete paving, dampcourse of two courses slates in cement, laid to break joint and projecting beyond walls externally to face of roughcast finish.

Form sill to window externally with double course tile creasing projecting 1½ in. beyond finished wall face, set and pointed in cement and internally with cement and sand render, splayed and trowelled smooth.

Provide mild steel casement size 3 ft. 3½ in. high × 3 ft. 3½ in. wide with side hung opening portion, build into opening with lugs provided and point up with maker's mastic.

Drainlayer. Lay 4 in. dia. second quality glazed stoneware pipes from foot of R.W. pipe and gulley position to existing soakaway, complete with all bends, junctions, elbows etc., laid to a minimum fall of 1 in 40, and joint with yarn and cement.

Provide square salt glazed stoneware trapped gulley to wash down, complete with iron grating etc., set on concrete bed and connect to new surface water drain.

Roofer. Cover roof with multi-coloured, machine-made, nibbed concrete-tiles to match existing tiled roof to house, laid to 4-in. gauge, nailed every fourth course with No. 2 1½-in. stout composition nails, finish with double tiles to eaves and with half-round tiles to ridge and hips. Bed up ridge and hips with hair and lime and point with cement.

Carpenter and Joiner. All timber employed to be red deal, dry, and well seasoned.

Frame roof to 45 deg. pitch, hipped back either end, with 4 × 2 in. plates, ditto common rafters at 14 in. centres, ditto collars to each rafter and 7 × 1 in. ridge piece, all properly halved, notched and spiked together, and batten with 1½ × 1 in. sawn battens spaced at appropriate intervals to suit specified tile gauge.

Bressumer over garage doors to be composed of two 6 × 3 in. timbers bolted together, with 6 in. bed either side.

Fascia to be 1 in. thick wrought and grooved for ¾ in. thick wrought tongued soffit board, and fixed to flush with the underside of the bressumer.

Ceiling lining. Line to underside of rafters and collars with asbestos wood sheets secured to every joist, and fix 1 × ½ in. cover slip all round at springing line.

Frames to garage doors to be 5 × 3 in. wrought, rebated and rounded, secured with iron dogs built into brickwork and dowelled to concrete paving.

Garage doors to be 7 ft. wide × 7 ft. 3 in. high, framed, ledged and braced, hung folding in two leaves, with 4 × 2 in. stiles, head and ledge, 9 × 2 in. bottom rail and 4 × 1 in. braces, lower panels filled in with 1 in. V jointed boarding, upper panels left for glazing in small squares with 1 in. vertical bars and loose beads for glazing.

Gate posts to be 6 in. square with splayed tops, 6 ft. long with creosoted feet, standing 3 ft. 6 in. clear of ground.

Provide the P.C. sum of £3 10s. for stock pattern folding gates of selected design.

Ironmongery to garage doors to comprise No. 2 pair 24 in. wrought iron cup and ball hinges, No. 2/12 in. iron barrel bolts fixed top and bottom on one leaf, and No. 1 cylinder night latch with No. 2 keys.

Ironmongery to gates to comprise

No. 2 pair 15 in. wrought iron double strap hinges, No. 1–9 in. iron barrel bolt, No. 1 stock pattern gate latch and No. 2 gate stops.

Smith and Plumber. Fix 4 in. deep cast iron half round gutters on all sides, jointed in red lead on brackets screwed to fascias, complete with angles, outlets etc.

Ditto 3 in. dia. down pipe, jointed as before and fixed 1½ in. clear of walls with pipe ears, nails, distance pieces, swanneck and shoe complete and connect to new surface water drain.

Glazier. Glaze window with 21 oz. O.Q. brand clear sheet and pin, putty and back putty.

Ditto upper door panels with 26 oz. ditto; bed in wash leather and fix loose beads.

Plasterer. Render walls externally, full height, in cement and sand 1 : 3 mix, average ⅜ in. thick, finish with similar coat but 1 : 2 mix and immediately dash with well wetted granite chipping of a shade to match existing pebble dash on house, to cover evenly the whole surface.

Painter. Knot, stop, prime and paint doors, frame, gates, posts, fascias and soffits, two flat undercoats and one matt finishing coat, green to match house, with white lead oil paint.

Scrape and scale iron casement, gutters, down pipe and hinges, prime with metal primer and paint three coats as to woodwork.

Property Survey

In very few cases is it possible to plot surveys in the property being measured and, therefore, it is essential that sufficient information be gathered to avoid the irritation and inconvenience of return visits. It is better to repeat measurements than to leave them out.

Do not assume walls run through or run up; always take measurements both inside and outside of rooms and buildings and prove it.

Always use "running" measurements as far as possible in preference to individual measurements, as this enables you to discover mistakes in tape or rod readings before leaving the building.

Always take diagonals. Because a room looks square, it does not necessarily mean that it is so.

Remember that it is an existing building that is being measured, therefore all readings should be taken to actual finishing surfaces. Do not attempt to add for plaster thicknesses to arrive at structural dimensions, otherwise your survey will not plot accurately. Details of construction should be dealt with when some decision has been made on the proposed alterations.

Never assume that a wall is brick because it sounds solid when tapped, nor that a very thick wall always denotes strength: it may have a rubble filling.

External Heights

When facilities are not available for measuring external heights, this is overcome, in the case of brick-faced buildings by counting the courses. To convert these into feet and inches, four courses should be measured centre to centre of mortar joints in several different parts of the structure; and the average rise should be used as the denominator. Where the external face of the building is rendered, heights from a constant datum, such as a plinth or dampcourse if exposed, should be taken together with heights between heads of windows on lower floors and sills of upper floors. This information, together with carefully taken internal heights, will enable the builder to plot these elevations.

Take time in preparing sketches, and don't worry about them being to scale. In fact, it is helpful to decrease deliberately the size of

large square rooms in relation to small rooms and cupboards as it is useless to take measurements and then find them too crowded together to be readable.

Taking measurements is the easier part of a survey; interpreting them is the harder.

Where things appear to be structurally wrong, find out the reason before passing on. Uncommon methods of construction must be taken into consideration when planning alterations.

Take note of floor joist runs, soil and R.W. pipes and general runs of drainage adjacent to the buildings. Such items often determine the method of altering property.

Survey of Land

The most popular way in which to tackle the survey of a normal building site is with chain and poles; that is, the ranging of straight lines adjacent to the boundaries, measuring the length of the sides of the site on the line of these poles by means of a chain, and simultaneously taking and measuring offsets at right-angles from the chain line to the actual boundaries.

To start a survey of this kind, first examine the site and carefully note any possible obstructions to chain and offset lines. Do not attempt to arrange chain lines to run parallel to the mean of the boundaries, but, having judged the rough shape of the field, arrange them to form a square, rectangle, right-angle or equilateral triangle, or triangles. Right-angles can be proved by taking diagonals before leaving the site, and equilaterals prove themselves. This also simplifies plotting. The number of offsets required will be determined by the curving of the actual boundaries, but, as in all surveying, it is never a fault to take more measurements than may seem really necessary while on the site. Plotting this type of survey is merely a matter of setting down the chain lines and projecting and linking up the offsets which give the outline of the actual boundaries.

In taking measurements on sloping sites, allowance must be made for the fall of the ground, as naturally all surveys are plotted on a horizontal plane.

If the site is to be levelled, carefully note the general falls in the site, and tentatively pick stations so that a wide range of levels can be read from each station. For instance on a field having a constant slope in one direction the first station would be chosen somewhere near the top of the slope. On ground falling away from the level, the scope for taking readings is very wide, having the full height of the staff; while on ground rising from the level, there is only the height of the instrument.

After a foresight has been taken, the staff must not be moved until the instrument has been reset and a backsight taken.

Bench Marks

Ordnance bench marks are not always near enough to sites to be picked up, and it is usually more convenient to fix a datum of, say, 50.00 and tie into a permanent bench mark, such as a threshold to a building or top of a stone gate-post. It is absolutely necessary to have a permanent fixed bench mark on all surveys,. to enable further levels to be taken at a later date, if required.

The ideal way to tie in any

levelling is to start on one ordnance bench mark and finish on another, as this not only proves the readings, but ensures that the bench marks have not, as sometimes happens, been moved, but where this is not possible it is necessary to tie back to the starting point.

It is important that all levels be reduced and proved before leaving the field.

Generally, all land surveys should take in any roads, paths and corners of buildings on, or adjacent to, the site. Positions of sewers, other mains and large trees should also be located.

Methods of Costing

Accurate costing of repairs and decorations to existing buildings is by far the most difficult task encountered, as the normal method of adding cost of materials plus man hours plus overheads is not at all satisfactory. The principal reason for this is that the number of man-hours involved, particularly on repair work, can never be assessed accurately. The amount of work necessary is not often clear until the faults are exposed, and this can seldom be done until after the estimate has been submitted and accepted; again, the amount of waste caused by using materials in small quantities makes accurate pricing difficult.

The best advice that can be offered to those starting a business without real knowledge of costing is to base their estimates for this kind of work on "inclusive" prices; that is, on prices "per yard", "per foot" or "per each", which allows for all necessary preparatory work, as well as the actual new work.

For instance, in pricing for painting the walls of a room previously distempered, it is better to base the estimate on a firm figure per yard for "washing off, cutting out cracks, stopping, and painting two flat under coats and one enamel", than to take the room as a whole and attempt to price each item separately. By this method also it is quite easy to adjust the fixed price per yard after the first few jobs, if it is found that outgoings are not being met; and—another point of importance—estimates can be prepared very quickly on this basis.

The above, however, is only a stop-gap method for use while the basis for future tenders is being prepared. This should be done by bearing in mind always that the successful builder must also be a successful book-keeper. From the start of the very first job a book should be kept showing the amount of all estimates against a very detailed summary of the actual costs.

Special Items

Travelling time should be entered separately and a remarks column for noting reasons where wide divergences from the estimated sums have occurred; whether property was occupied or vacant; starting and finishing dates; clients' remarks; changes in prices of materials; and wage rates and any other relevant remarks. After a while it will be found that there is hardly a job which cannot be covered by reference to the information collected; and, if faithfully kept, the book, together with constantly widening experience, will prove an indispensable guide in estimating accurately the cost for this exceedingly difficult class of work.

(B.R.)

SCHEDULE OF DILAPIDATIONS required to be executed at ....

Room.	Item No.	Description.
Sitting Room.	1	Take off broken finger plate to door and renew to match or as approved.
	2	Take out cracked pane in lower left-hand window; reglaze with glass of equal weight and quality and touch up paintwork to match outside and in.
	3	Fill holes and make good to window architrave where blinds removed and touch up paintwork to match.
Dining Room.	4	Hack out broken and cracked tiles in hearth, renew to match and point up or take up hearth tiles complete, hack for key, screed and lay tiles of approved pattern.
	5	Strip paper, torn and disfigured, on all walls and prepare for and hang new paper P.C. 3*s*. 6*d*. per roll and border P.C. 9*d*. per yard.
	6	Wash off ceiling, discoloured through water percolation, Clairecolle, and twice colour wash to match existing.tint.
	7	Rub down door framing only (leave panels), worn and dirtied by handling; bring up worn section and paint one coat eggshell finish to match existing.
	8	Make good to window architrave as described under Item No. 3.
Kitchen.	9	Provide and fix new chain and rubber plug for sink.
	10	Make good angle beads to tile splash back behind sink with tile beads to match existing.
	11	Take off rim lock to external door, provide and fix new spring, refix lock and provide new key.
	12	Wash down, prepare and twice distemper grease-splashed walls on all sides, with oil bound water paint to match existing shade.
Hall.	13	Take off rusted bolts to front entrance door; scale, scrape, paint, grease and refix.
	14	Rub down, twice stain and varnish handrail and newel caps to match existing.
Large Front Bedroom.	15	Nil.
Small Front Bedroom.	16	Remove guard bars from window, make good holes and touch up paintwork to match.
	17	Strip nursery pattern paper from walls, stop as required and reinstate equal to original decorations. Rub down paintwork, scratched and marked on all joinery, bring up and paint one flat coat and one full gloss coat, oil paint to match existing colours.
Back Bedroom.	18	Remove cupboard door, take apart and renew smashed plywood panel, reassemble, rehang and paint to match other work.
	19	Take out broken power plug point, provide and fix new, make good to skirting and touch up paint.
	20	Replace missing fret to fireplace or provide new.
Landing.	21	Take off broken casement stay to window and provide and fix new. Rub down scratched and dirtied paintwork to trap door and linings and paint two coats flat oils and one coat clear varnish to match elsewhere.

SCHEDULE OF DILAPIDATIONS—continued

Room.	Item No.	Description.
Bathroom.	22	Disconnect and take out cracked lavatory basin (leave brackets) replace with new basin to match, refix existing taps, reconnect to trap and services, leave perfect and make good to walls disturbed with Parian.
	23	Make good to walls where cabinet removed with Parian.
	24	Rub down walls, all disturbed; bring forward on new plaster and paint one flat coat and one enamel coat, full height, to match existing colours.
Externally.	25	Remove broken grating to gulley outside kitchen and replace with new to match.
	26	Renew broken norfolk latch to side gate.
	27	Replace missing lid to dust-bin.

In estimating for new work it is often necessary to give the client a tentative cost when the drawings are at sketch plan stage only. There are several quite simple ways of doing this, two of which are as follows:

Squaring. This consists of measuring the superficial feet of floor area contained in the proposed building and multiplying by a fixed rate per square foot. For example, a bungalow 40 × 20 ft. at 10/- per sq. ft. would be:

40 × 20 ft. = 800 sq. ft.
800 × 10/- = £400.

Cubing. A slightly more accurate method than squaring, but still only of use as a general guide. The cubical capacity of the building is obtained by multiplying width × length × height, the height usually being taken from underside of concrete over site to, in the case of pitched roofs, halfway between springing and apex of roof; and, in the case of flat roofs, to 2 ft. 6 in. above roof covering. A rate per cubic foot is then fixed and multiplied by the quantity of cubic feet. Taking the same example again this would be:

40 ft. × 20 ft. × 12 ft. 6 in.
= 10,000 cu. ft.
10,000 × 10*d.* = £416 13*s.* 4*d.*

As in the case of the first method, rates can only be fixed with any degree of accuracy after long experience and study; but dealing with smaller units should, of course, bring the price much nearer to the true figure.

Before a firm tender can be submitted it is necessary to have working drawings together with a specification, unless all information is noted on the drawings. From these a bill of quantities should be drawn up itemising in every detail the exact quantities of materials required and describing the work entailed.

Dilapidations

As a general guide to the form which a schedule of dilapidations should take, a six roomed property which has been let on agreement for three years is given as an example on pages 290–291. The tenant is responsible for leaving the premises in the same state of repair as existed on occupation, subject to fair wear and tear.

CHAPTER 14

BUILDERS' OFFICE WORK AND ROUTINE

ANNUAL TURNOVER. CHANNELS OF BUSINESS. TYPES OF WORK UNDERTAKEN. BUSINESS POLICY. MAINTENANCE OF RECORDS. JOB GROUPING. PREPARATION OF SPECIFICATIONS. ORGANIZATION AND DUTIES OF STAFF. TRANSPORT. HOW TO FORM A COMPANY. LIABILITY OF MEMBERS. PRINTING REQUIREMENTS. RETURN OF DIRECTORS. DECLARATION OF COMPLIANCE.

Builders' office work and routine vary in relation to the amount of the annual business turnover, as well as to the volume of work undertaken. Conditions of the work, and whether the work is in a local area or at a distance, are also important factors. The guidance given here is deemed to be of service to jobbing builders, foremen and craftsmen. As these have all been trained in one or other of the building trades, their knowledge is usually of a practical rather than a clerical character.

Starting a Business

Building businesses are not infrequently started by some craftsman who, having studied the theory as well as the practical side of building, decides to undertake building repairs and odd jobs.

In the early stages of starting a business the builder generally uses his own home as his headquarters. Many large building firms have grown from very small beginnings, and this chapter is, therefore, framed to give information on business procedure to all those whose businesses are likely to develop in such a manner.

The yearly turnover roughly indicates the value and the amount of business transacted during the year, for it includes the sum total of reimbursement monies due for collection as payment for work executed. The small builder's business does not give scope for examining the staff work because the turnover of capital is not sufficient to justify employing staff officers.

Assuming that a builder in a small way of business, employing some twenty workmen, which indents half of them from subcontractors, turns over approximately £10,000 per annum: 5 per cent would yield £500. On the same basis a builder employing 2000 workmen might be expected to approach a turnover of £1,000,000 per annum. In the first case the builder can give personal attention to all business matters, but in the second case he must rely on assistance or staff to undertake routine duties.

To strike a useful mean, it is proposed to examine the office and staff work of a building firm employing directly, and indirectly through auxiliary services, 500 workmen and having a yearly turnover of say £200,000, an amount which would involve most

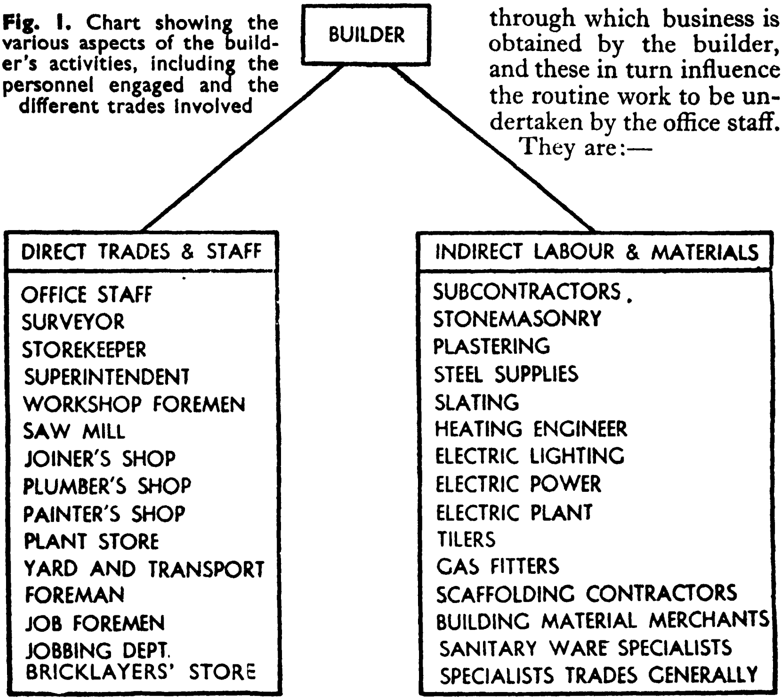


Fig. 1. Chart showing the various aspects of the builder's activities, including the personnel engaged and the different trades involved

of the usual business routine, and which would necessitate the employment of a reasonable grouping of staff and an up-to-date business system.

The builder's routine work has to include business dealings with persons and firms of the nature of those shown in Fig. 1, which has been divided into directly and indirectly employed labour. The labour directly employed is provided by the trades which are usually on the builder's pay roll, the labour indirectly employed being supplied by subsidiary firms whose less frequently demanded services are placed at the disposal of several building firms.

Business avenues are illustrated in Fig. 2.

There are three main channels through which business is obtained by the builder, and these in turn influence the routine work to be undertaken by the office staff. They are:—

(1) The client who knows exactly what he requires and can specify his requirements to the builder, makes a *direct* approach;

(2) The client who lacks the knowledge of the customs and practices of the building trade, and desires independent supervision of the proposed building, and who, therefore, employs an architect as his agent;

(3) The client whom the builder *seeks* and for whose business he will undertake to tender and carry business risks.

A builder's business budget of £200,000 annual turnover, split up into sections as illustrated, could reasonably be divided as follows into the work which is directly undertaken for clients:—

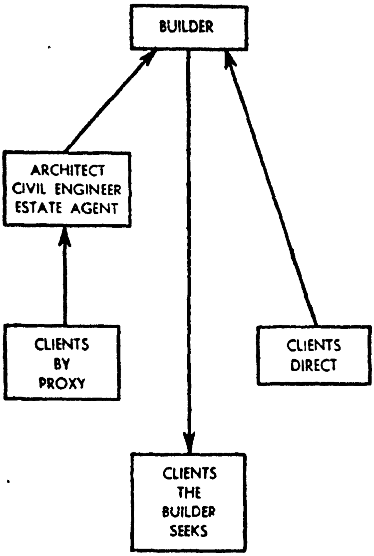


Fig. 2. Principal channels of business which are open to the builder.

(*a*) Jobbing repairs and alterations; (*b*) commercial undertakings, plant, etc.; (*c*) constructional work offered without competition; (*d*) works and building maintenance; (*e*) work on profit percentage basis to an amount of, say, £100,000; (*f*) government work and council contracts tendered for in open market; (*g*) favoured contract constructional work executed on agreed price schedule, through client, architect or engineer; (*h*) sub-contract work for other builders in special lines, such as wood-finishings, Portland or other building stones to a further value of £100,000.

Business policy may either aim at slow and steady progress with equity and fairness in charges for good standards of work, which in turn produce repeat orders and recommendations by satisfied clients; or the opposite policy, which provides no foundation and rarely obtains a second job from the same client.

A successful business organization carefully weighs up the many aspects of the jobs available, and seeks work suited to the capacity of the firm's plant, machines, labour, material and working capital, arranging for the administration and budgeting for the "working float" necessary.

Classification of Charges

Practically all charges on the business are rendered in account form, but for business reasons these charges must be collected under classified headings for easy reference and ready allocation to origin. There is always a temptation to reduce records to the minimum and to trust to memory, but, taking the long view, it is false economy; and the demands on a builder's time do not allow of his having to search his memory for details of any given job.

The builder is in business to make a profit, and business policy, organization and routine are vital factors to that end.

Essential Practice

Business routine requires that all items of work should be executed under a distinctive job number.

All wages paid should be liquidated by being charged to some job number undertaken for a client or debited to some business service job number.

All purchases of material, including petty-cash purchases or expenses (Fig. 3), should be debited to the job receiving the service, or charged to stock if obtained for that purpose.

All purchases should carry a written requisition for supply

PETTY CASH EXPENSE VOUCHER

Week ending Friday .... 194...

N.B.—Receipts to be attached for purchases and other expenses if possible.
All charges to be initialled by departmental head and check-initialled by management before payment.

Date.	*Particulars.*	*Job or Code No.*	*Site, Job, and other charges.*			*Direct Works charges.*		
			£	s	d.	£	s.	d.

SITE WORKS TOTAL

Signature..

GENERAL AND WORKS DEPOT TOTAL

Authorized for payment.......................

Fig. 3. In the maintenance of accurate records it is essential that all purchases of material and other expenses be debited to the service job number for which they are incurred, and for this purpose the above form is employed.

(Fig. 4) and be signed by the authority originating the demand, thus enabling the stock or monies expended to be readily traced to source.

All receipts of material received should be entered in detail in the *Goods Received Book* for later checking invoice charges.

All wages, purchases, expenses, with other charges, should be abstracted for debit to the correct expense service; also stocks carrying items subject to conversion and manufacture, in order to ensure their ultimate debit to client or business, and for review in any case of irregularity which might arise.

Work executed by a business having a turnover of £200,000 per annum would be organized to class the different jobs or contracts under their respective heads, and distinguishing job numbers serve admirably in this connection, as:—

Jobbing Group No. 1.—Day work rates for jobbing repairs, decorations and alterations. Day work rates for commercial and industrial undertakings. Works and office regular building and plant maintenance.—Separate order numbers range from 1/01 to 1/999.

Group No. 2.—Construction work executed on profit percentage basis. Construction work executed on lump sum profit.—Separate order numbers range from 2/01 to 2/999.

Group No. 3.—Building work on Favoured Contract basis. Building work on competitive contract basis. Building work on priced schedule based on measured work.—Separate order numbers range from 3/01 to 3/999.

The procedure which is associated with the creation of a jobbing order number is shown herewith.

REQUISITION FORM FOR STOCK OR MATERIAL ON STORES

DEPARTMENT.. DATE.................194...

Position or Job No. requiring.	*Material.*		*Stores physical Number.*	*For allocating cost use only.*		
		Description.				

DEBIT TO STORES STOCK CARD

Signature .... *Officer requiring*

.............................*Storekeeper or Clerk*

Date ....

Checked by .... *Person receiving*

ADJUSTED IN COST RECORD LEDGER

.... *Clerk*

Date ....

NOTE.—If quantity detailed not received amend figures in red ink to agree with actual amount received.

Fig. 4. Requisition form for stock or material on stores. This form enables stock and monies expended to be quickly traced to source and also provides a permanent record of the authority from which the demand originated.

A builder receives a letter by hand from a client reading:—

Bull Buildings,
Bull Road,
Bull.
5.6.4 .

Dear Sir,

Please send workmen to above address at your earliest convenience to repair the roof, doors, windows, plaster, and electric, gas and water installations; and supply particulars necessary for advising the War Damage Commission as to the extent of the damage.

Yours faithfully,
JOHN BULL.

In the letter the builder obtains a direct commission to undertake the necessary repair work for Mr. Bull. He takes direct action either personally, or through his surveyor or superintendent, by visiting the property and inspecting and estimating the damage, and by preparing a specification of the work to be done on the following lines:

Brickwork. Cut out and re-tie the internal 4½-in. wall with the front wall before restoring wall plaster. Repair with concrete, cast *in situ*, the broken stone window-sill. Shore, cut out and repoint the damaged doorway, arch and jamb, to opening.

Point up the window frame after refixng.

Carpenter and Joiner. Repair the front door with new stile, also repair broken glazing bars of top panel and refix and reglaze the panels. Provide and fix a new 5 × 4 in. rebated door frame to back door and rehang the existing door, including making good door locks and furniture.

Ease and refix as necessary the bedroom doors after replacing broken panels and leave in good condition, including replacements of broken furniture parts—locks, keys, and knobs.

Refix and repair, with new timber as required, the dividing wooden fencing laid flat by bomb blast.

Refix the displaced casement window-frames; bed, wedge up and leave firmly set before making good plaster.

Plastering. Remove burst, sodden and cambered ceilings, loose and burst plaster to window frames, broken and open wall plaster, with cracked and burst cornices, and replaster throughout, including finishing the wall and ceiling intersection with a plain filleted cavetto moulding of 6-in. girth throughout all defective rooms.

Make good the dividing partition with plaster boarding in place of the damaged and warped S.X. board.

Apply cement rendering to the under window sill panel.

Repair by patching the damaged ceiling and wall facings around the window frame in scullery.

Electricity. Test out the installed systems of conduit wiring, switches, distribution boxes and fittings for being regular. Correct all irregularities in sequence with other trade repairs and leave in good working order.

Water. Make good the domestic hot water flow and return pipe services and leave in good working order.

Glazing. Replace broken leaded lights to casement and staircase windows with Cathedral, Flemish or other approved 32-oz. semi-obscured glass. Reglaze front ground and first floor, side and back broken window-panes with 32-oz. clear glass.

Painting. All new woodwork and putty pointing to glazing to be prime coated. The redecorations to be deferred until all new plaster has dried out, with the exception of preparing and coating wall plaster with 2 coats of Duresco distemper.

The letter of Mr. Bull provides the instruction to execute repairs, so this document is filed as authorization and a job number given to identify the cost concerned. A jobbing dept. works order, say No. 1/01, is issued, worded to include the detailed items of the work to be undertaken as on Fig. 5, and right through to completion and account stage it carries that number.

Proceeding, the manager of the jobbing dept. obtains and allocates the labour and material required for all the specified repairs. He places orders with subcontractors for labour and materials not directly employed or supplied by the builder. Plastering would probably be a subcontracted service in this case. The above administrative routine steps are common to all classes of work the builder accepts for executing.

Duties of Staff

The builder cannot undertake all the business sections direct, so he employs a staff to collate the business records with system and method to ensure that all transactions, especially all labour and material charges, are compiled in a form that discloses the assets and liabilities of the firm.

Cashier: From the records compiled by the cashier the builder should be able to know at any time his financial standing, *i.e.*, what the debit and credit relations are with builders' merchants, subcontractors, bank and clients' accounts. He should know details of the recurring charges to which he is committed for the payment of

Builders' Business Works Order

Department Order No.	Contract : ....
	Jobbing : 1/01 ....
	Works : ....

To: Jobbing Dept. Manager

Please execute work and repairs for
Client:-
John Bull, Esq.,
Bull Bldgs., Bull Road, Bull.

including: War Damage repairs to roof, doors, windows and plaster finishings together with Electric, Gas and Water Service repairs in accordance with the accompanying specification.

Authorised by J.H.N. **General Manager.**

N.B.—Materials, Labour, Machine, Transport and all other direct expenses incurred for the above client whose work the firm is executing are to be charged to the above order number.

Fig. 5. Specimen of a typical builder's works order form giving the job number and the detailed items of the work which is to be undertaken.

salaries and wages, as well as expense items such as rates, taxes, mortgages, ground rents, workmen's compensation, heating, lighting, telephone, petty cash and cleaning charges, together with capital invested in buildings under construction, furniture, fitments, plant and tools. The cashier in short keeps records of all monies in hand, due for payment or owing to the builder; from the records compiled he supplies the Income Tax department with the monthly or quarterly Government returns.

Cost Clerk: The cost clerks compile records that show profit and loss undertakings. They classify under the physical job numbers all the labour and material charges that accrue to each job number, showing the earnings and expenses of the business as a whole. For example, the work of a bricklayer

engaged on setting bricks yields a direct return for the labour expended—it is work that can be measured and valued; but that condition does not apply to the services of a storekeeper, foreman, watchman or mess-room attendant. Services of this character are common to the whole and to recover the charges the cost dept. group them together for spreading over the job they serve, as a percentage charge on work that can be measured and valued.

The cost clerk's records also assist in obtaining reliable cost values for repeat estimates for similar classes of work.

Chief Clerk: Builders' staff and routine in all businesses claim the services of a chief clerk, who functions in a general way including serving as proxy for the builder himself. The chief clerk negotiates with all and sundry callers, such as travellers, also clients who make personal calls concerning specified instructions with regard to property repairs.

The chief clerk interviews applicants for work, receives letters and parcels, distributes correspondence, dispatches telegrams, and receives telephone messages. He serves as a clearing centre for messages to staff from job foremen, surveyors, architects, subcontractors and specialists. His duties include supervising the filing, and junior clerks' work; maintaining the records of goods received and empties returned, with "broken or damaged in transit" claims ready for the clerk who is responsible for the checking of invoices.

The chief clerk also receives requisitions for purchasing building materials; places the orders; circulates copies of the placed orders to interested parties. He superintends the copying of extra typed sheets of quantities to obtain tenders for subcontractors' and specialists' work, and similar general business.

The *Wages and Labour Clerk* undertakes sectional work that recurs weekly. The worked labour hours flow in to head office from all service points employing labour, chiefly through depot and sites with work in progress. The worked time-records are collated on separate wages sheets (Fig. 6) for each contract, and thus record the requisite monies to be forwarded for the payment of wages on each site. These monies paid out in wages are duly debited

WAGES SHEET

NAME OF BUILDING SITE .... JOB NO. ....

Week ending .... 194... SHEET NO. ....

Check No.	Name	T., O.T. after 5 p.m.	F.	S.	S.	M.	T.	W.	T.	Time payable	Total hours	Rate	Wage total	Wage* transfer	Fares	Gross wages	Income tax deduction	Insurance Firm	Insurance Men	Net wages
													£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.			£ s. d.

Fig. 6. Method by which the General Foreman advises his firm of wages due to building site workers each week. The "Wage transfer" column is the workmen's transfer record when dividing service between building sites for payment of wages at the site on which the worker is employed on pay day.

to the builder's account books and provide at the same time the check on the workers' or foremen's labour hours returned as abstracted by the costing department.

The wages clerk is further responsible for maintaining a labour register with name, address and other particulars of every person employed by the builder. He is also allocated the care of Health and Unemployment Insurance cards and their stamping, receipts for cards being obtained at time of returning to their owners.

Surveyor and Estimator: the builder with a business turnover valued as previously detailed generally employs an estimating surveyor, whose qualifications and experience allow of his assessing the money values of specified items of prospective work.

Builders undertaking repair work are repeatedly requested to give an estimate to owners of property for redecorating their dwelling-houses. The value of the work required is arrived at by scheduling the work services item by item with dimensions, which when worked out into super feet measurements with specified labours, form the basis of the money value for labour and materials required.

Take a common item:

Supply labour and material, burn off, rub down, prime and apply three coats of paint to all wood surfaces, finishing with a glossy or flat coat, for 240 ft. super in a total of 12 sash- and frame-windows.

The item given is one of many so frequently repeated that with constant practice and knowledge the cost of such repeat items (with practically the same labour and material supplies), allow the builder to quote a price on the spot. Repairs to brick walls, dropped brickwork in defective arches, shoring and underpinning settlements, renewing roofing tiles and lead flashings, dry-rotted timbers in floor and roof, are in a different category, and often require to be inspected by opening up before the full extent of the dilapidations is evident.

The surveyor has knowledge and experience in constructional detail, and is able to visualize and specify the labour and material as well as to value the labour and material required for repairs.

The Works' Superintendent should be essentially a man well versed in all the work of the tradesmen and other labour employed by the builder as well as having a good knowledge of all subcontracting trades and with building materials generally.

The builder's supervision can only be superficial—the superintendent serves in filling-in the detail of actual building or repair work. The superintendent must be equal to gauging the ability of the foremen under his control, and to assist in organizing and setting out building and repair work of varying character. His duties with the builder include:

Engaging and allocating workmen direct or through a foreman subject to his supervision.

Acting as liaison officer between the site of operations and headquarters in such matters as the supplying of necessary stationery and business forms, tools, plans, sheds, stoves, framings or other supplies for the depot workshops. Acting as liaison officer between site owner and the local district surveyor and sanitary inspector; accepting responsibility for drain connections, drain testing, and

FOREMAN'S DAILY DIARY SHEET .... 194...

WEEK..........................

TIME LIMIT—WEEKS..........................

.... WEATHER..

Firm's workmen employed on site	*Charge-hands*	*No. of men*	*Name of sub-contractors*	*Foremen*	*No. of men*	*Visitors*
Foreman and staff						
Plumbers						
Do. mates						
Steel benders						
Fitters, etc.						APPROXIMATE WORK DONE :—
Do. mates						
Electricians						Excavating, cub. yd.
Scaffolders						
Do. mates						Concrete, cub. yd.
Carpenters and joiners						
Do. do. labourers						No. of bricks
Plasterers						
Do. labourers						Stone, cub. ft.
Painters and glaziers						
Do. labourers						Steel, tons
Masons						
Do. labourers						Timber, bulk
Bricklayers						
Do. labourers						,, boards
Slaters						
Tile layers						
Steel erectors						PROGRESS
Concretors						Record work in hand and state of building. Commencement or completion of any section should be noted here.
Navvies						
General labourers						Particulars of drawings received on site.
Off-loader						
Crane drivers						
Mess-room attendants			TOTAL			
Messengers						
Miscellaneous			CLERK OF WORKS AND ARCHITECT'S VISITING STAFF			
TOTAL						
TOTAL ON SITE			TOTAL			

MEMORANDA

General remarks of interest. Likely memo. for guidance and reference. Delays—cause and duration. Accidents—circumstance and action taken. Work delayed or material rejected, and by whom, etc., etc.

Building Foreman

Fig. 7. Report sheet which is prepared by Foremen when engaged on country jobs.

FOREMAN OR STOREKEEPER'S RETURN OF GOODS RECEIVED OR DISPATCH OF PLANT, etc.

NOTE TO FOREMAN.—Report all goods received on site, whether unpacked or left in crates, how signed for, shortages, breakages; also use this return for recording dispatches, transfers of material, plant, tools, etc. Foreman to retain carbon or other copy for site reference.

Trans-port medium.	*Suppliers.*	*Order No.*	*Description of goods.*	*Quantity.*					*Ad-vice No.*	*Distribution.*	
				Count.	*Tons.*	*Cwt.*	*Qrs.*	*Lb.*		*Stock.*	*Job No.*

Fig. 8. Goods received form. A record of material, plant and tools received.

for complying with by-laws and regulations; smoothing out all difficulties experienced in construction; being responsible for repair work and for the expeditious and efficient execution of all new work.

He arranges the labour requirements with transfers to other work in hand to suit the demands of trade sequence, including negotiations to ensure that subcontractors and specialist workmen arrive to execute their sectional work, and to avoid delays and displacement of labour that could otherwise be retained.

Foremen of Site, Works and Repairs: The job foreman is a full-time service officer in charge of the administration, labour and materials at a building or repair site, responsible for keeping head office in touch with all vital records concerned with the constructed work under his charge. He maintains a time record of workmen's time service in the job interest, as shown in the *Wage Book* (Fig. 6), and returns to Head Office each week a copy of his wages as booked to each employee. He collects from employees engaged on the site Health and Unemployment Insurance cards and claims for stamps if obtained direct, or forwards to Head Office for safety and stamping.

In country jobs he sends to Head Office a daily or weekly report of matters affecting the work (*Daily Diary Sheet*, Fig. 7) together with daily *Goods Received* form (Fig. 8) which describes material and plant and tools received. The form contains records of materials delivered, noting shortages as compared with advice note. It also takes cognizance of damaged and broken items.

Having been supplied with a copy of the order, he calls attention to any variations. He accepts for his employer direct instructions from the client, his architect or other authorized representative, and attends during their visits of

inspection. In the case of site measurements check, or of the amount of excavating, concrete, brick-work already carried out, the foreman checks what is to be paid for on schedule of prices or contract rates. He keeps receipts of monies paid out and returns particulars of petty cash payment (Fig. 3), carriage on goods delivered, payment for telephone and telegrams. He is responsible for all scaffolding being correctly assembled, tied, braced and equal to support the loads to be carried; also for all hand and power plant being installed and manned by experienced labour, such as the opening-up and cleaning of boilers for the Assurance Co. inspectors, care of cranes, electric or petrol-driven motors, with all the necessary H.M. Factory Inspectors' regulation sheets.

The foreman is also required to keep stocks of unused materials, and to forward returns of same at stated intervals to Head Office. He serves as liaison officer between his employers and subcontractors and specialist workmen engaged on the same building project, and generally ensures the direct and indirect labour being employed in its correct sequence.

Sectional Trade

Depot Works and Foreman: Builders who specialise in sectional trade and repairs (as timber merchant; saw-mill and joinery works; stone, saw and planing works; masonry work; plumbing; decorating; painting; polishing; plant and electrical repairs), employ foremen with craftsmen and unskilled labour proportionate for the work undertaken, all of which sections fit into the office routine record work previously described.

There are cases where these workshops manufacture special articles or undertake subcontracting work for sectional parts or finishings of buildings that are not under the control of the builder, and act towards the parent business as a separate or associated company. When the latter policy obtains, the organization includes an estimating department for submitting tenders for work offered in the open market and for competing with other firms.

Additional Work

It will be appreciated that any such workshop, well served with orders that not only cover the overhead charges but leave a fair profit margin, is in a very favourable position to take on extra work, to the full capacity of men and machines; for the simple reason that the overhead expenses of the chief business have been liquidated, and the bulk of the extra work can therefore be executed on a low estimate. On the other hand, workshops with little work on hand have either to be loaded with the heavy oncosts or the latter must be carried by the parent firm for the time being, as a quiet time business loss.

Storekeeper: Material stocks represent the expenditure or investment of capital. Stores cannot always be classed as a business asset, because as they get out of date or depreciate with weather or age, they can readily become a liability. When, for instance, they remain on the record returns at stocktaking periods with little chance of issue, such material occupies space in the stores section, the stocks in which should normally bear a proportionate share of the overhead rent and

rates, in addition to insurance and maintenance charges.

The care of stocks of material requires that: Every item of stores should carry a physical or Code identity number; and that every item received or issued should be recorded for reference, to liquidate the stock or debit to service point or job used. New plant and tools should be separately block grouped, and the coding arranged automatically to differentiate between old and new plant and tools, in order to maintain fair charges against jobs using these proportionate to their life and wearing qualities. Some tools wear quickly and require frequent replacement.

The records should be kept to show a theoretical check of stock in detail items at all times, and full value of the whole of the stocks by collation.

Testing of material supplies when necessary is allocated to the storekeeper, who keeps the stock clean and serviceable, especially in the case of leather, metals, and other materials likely to waste. Attention is also necessary in replacing coverings to prevent tarnishing and other forms of deterioration.

Stocktaking

The storekeeper's service includes the work of stocktaking once each year, usually at Christmas or New Year, and the results are compared with the ledger stock card (Fig. 9) records maintained under the care of the costing clerks.

Coding stock materials by physical items means dividing the stores into groups that carry a distinguishing number, as:

Ironmongery coded, say, as 20/, but having a tail number to distinguish the varying kinds, *i.e.*, 20/1 6-in. tower bolt; 20/2 6-in. monkey tail bolt; 24/1 3-in. rain

MATERIAL STOCK LEDGER CARD

DESCRIPTION OR NAME ....

SIZE ....

BIN NO. ....

RECEIVED

Order No.	Date.	Supplier.	Weight.				Quantity.	Rate.	Amount.		
			Tons.	Cwt.	Qrs.	Lb.			£	s.	d.

Fig. 9. In order to facilitate the work of storekeeping a Material Stock Ledger Card is usually employed. By this means the storekeeper is enabled to determine

water C.I. pipes 6 ft. length; 24/10 3-in. L.C.C. heavy pattern C.I. pipes 6 ft. length.

Transport: The member of the staff responsible for transport would be allocated the care of the motor-cars and lorries. He would arrange to augment during shortage by requisitioning extra supplies from local haulage firms.

Care of Vehicles

The care of the vehicles includes supervision of each unit as fit for the road in such matters as: water, petrol and oil supplies, lubrication, tyre wear and inflation, battery charging, brake linings, and attention to tail load number plates.

The transport department is a clearing-house for receiving requisitions by road, rail or canal; the arranging of motor lorry journeys; loading up at depot or goods wharf or station, the dispatch and collection of plant as well as materials.

Vehicle depreciation is reported and specifications of motor vehicle repairs are prepared and the account charges checked and passed.

The *builder's office staff* functions on similar lines for recording business transactions, the information it compiles being supplied by work executed whether as day work or contract. The jobbing day work is often more a personal matter between the builder and his client regarding some building defect, damage or alteration, while the contract with its accompanying drawings and specification submits a definite constructional programme.

Jobbing and Contract Work

In practice builders who combine jobbing and contract work have a business asset in the nucleus of tradesmen and labourers who are always available for odd services because they are

PHYSICALLY NUMBERED

PEAK QUANTITY AMOUNT ....

RE-ORDERING QUANTITY AMOUNT ....

ISSUED

Stock in hand.	*Date.*	*Requisition No.*	*Job allocation.*	*Weight.*				*Quantity.*	*Rate.*	*Amount.*		
				Tons.	*Cwt.*	*Qrs.*	*Lb.*			*£*	*s.*	*d.*

the exact position in the stockroom at any time by comparing the actual amount of stock in hand with the amount of stock which is shown on the Stock Ledger Card.

regularly employed on jobbing work. The advantage is not so patent with builders who undertake contract work only. In their case it means starting and stopping workmen for small oddments that must be cleared as they arise.

On the other hand jobbing work may prove a plus or minus quantity involving the builder in maintaining his workers by undertaking standby work for void periods as a part business expense. Definite contract constructional work can be visualized and plotted on time schedule lines, anticipating and releasing the labour requirements to dovetail in with constructional progress.

On contracts labour serves in a consecutive and regular manner, more often than not being engaged on the job, while in jobbing the builder's yard is the starting point, with travel-time to and from the working point, coupled with the inevitable lag between finishing one job and starting another. Reimbursements in the way of establishment and profit charges are not as generous as War Damage day charges at 15% on cost, nor is the turnover likely to be as frequent on contract as compared with that of jobbing.

Forming a Company

In order to expand his jobbing business, a builder may well find it advisable to turn it into a limited liability company. The following notes on the procedure necessary for taking this step, and some general information in regard to company formation will be, therefore, of interest.

The Companies Act, 1929, provides that two, or more, persons applying to the Registrar of Companies may be formed into a limited liability company.

A number of advantages accrue to the builder who converts his business into a limited company. These include the following:—

(1) The liability of the members is limited to the amount remaining unpaid upon the shares for which they have agreed to subscribe. Usually this means that they are not required to contribute anything to the assets in the event of liquidation, and safeguards their home and private property.

(2) Continuity of the business is ensured, as upon the retirement or death of the owner, or a partner, it is only necessary for the shares to be sold in order that the business may continue.

(3) The company can arrange finance easily and give security, by way of debentures, for loans.

Procedure

It is not necessary for an expert to be employed in the formation of a private company, and the steps to be taken are as follows:

(1) Decide upon a suitable name and then make application to the Registrar of Companies as to whether this particular name is available.

(2) Having received a reply that the name may be used, ask a firm of law printers to send a representative.

(3) The printer's representative will submit specimen forms of Memorandum and Articles of Association suitable for a builder's business, and quote an inclusive fee for printing twelve copies of these for the company; and for supplying the necessary forms, the statutory books and the seal.

(4) The following details must be given: (*a*) the name of the

Company; (*b*) the nominal share capital, and its sub-divisions; (*c*) the names of the original directors; (*d*) the name of the secretary; (*e*) any other special details required.

(5) Within a few days the printer will supply two printed forms of Memorandum and Articles of Association, complete except for: (*a*) the number of the Company; (*b*) the date of incorporation; (*c*) the names and addresses of the subscribers.

(6) Spaces for 5(*c*) will be provided at the end of both the Memorandum and Articles of Association, and in both of these must be written in the presence of a witness: (*a*) full name of applicant; (*b*) full address; (*c*) description of business; (*d*) the word "one" to signify the minimum number of shares for which an applicant will subscribe.

(7) If there is a partner he must also sign; if there is no partner, however, a relative or friend should be asked to sign.

(8) The witness should then write his name, address and description. These details should then be copied on the spare form which should be retained for future reference.

Forms to be Lodged

The following forms, which will have been supplied by the printer, have then to be completed:

(a) *The Situation of the Registered Offices.* This should be the principal place of business.

(b) *The Return of Directors.* This should be a full list of all the directors, their addresses, and descriptions as set out in the form.

(c) *The Declaration of Compliance.* An affidavit by a director, or secretary, named in the Articles of Association, in which it is stated that the statutory requirements have been fulfilled.

(9) The signed Memorandum and Articles of Association, together with the above three forms, should then be sent to the Registrar of Companies with the necessary fee.

Company Fees

The fees are as follows: (*a*) for every £100 of the Nominal Capital, 10*s.*; (*b*) a fee on the Memorandum, according to the Capital. Up to £2000 this is £2; (*c*) a deed stamp on the Memorandum and Articles of Association, £1; (*d*) a fee on each of the returns and the Articles of Association, 5*s.* For a company with a capital of £100 the fee will be £4 10*s.*; for a company with a capital of £500 the fee will be £6 10*s.*; for a company with a capital of £1000 the fee will be £9; for a company with a capital of £2000 the fee will be £14.

Certificate of Incorporation

(10) Providing these documents are in order, the Registrar will then send a Certificate of Incorporation. This will show the number of the Company and the date of incorporation. This information should be entered on the spare form of the Memorandum and Articles of Association which should be returned to the printers, who will in due course supply the completed printed Memorandum and Articles, the statutory books and the seal.

Thus for the modest outlay on fees and printer's charges a company can be quite simply formed.

CHAPTER 15

PLANT, EQUIPMENT AND STOCK

BUILDER'S LAY-OUT. ARRANGEMENT OF OFFICE, YARD, STORES, WORKSHOPS AND EQUIPMENT. GENERAL MAINTENANCE OF PROPERTY. JOBBING BUILDER'S EQUIPMENT. JOINERY. PAINTING AND DECORATING. PLUMBING AND SANITARY ENGINEERING. HEATING AND VENTILATING. BRICKLAYING. MASONRY EQUIPMENT AND STORES. SLATING AND TILING. PLASTERING MAINTENANCE. ELECTRICAL PLANT AND STORES.

PLANT, equipment and stock of each separate builder's business naturally follow the class of work peculiar to the district in which the small builder undertakes building repairs and alterations.

Dwelling-house repairs are common to all districts, and indeed in many districts they are the first thought in the provision of plant and equipment; but in practice the majority of builders' businesses undertake building repairs for all other classes and types of buildings.

Hundreds of country builders cater for repairs connected with agriculture, such as barns, ship-pens with stall fittings, stables, loose-boxes, estate fences, gates and stiles, and carry plant and stocks to suit.

Industrial Requirements

In the industrial town and city areas the nature of the plant and equipment carried caters in a small measure for the special district industries—small because the industrial firms themselves provide and maintain lifting blocks (chain and rope), and winches, which may be required when the builder is called upon to supply experience and trade skill. The manufacturers draw on local building firms for repairs to sheds and buildings. .

Local Demands

The Durham builder could reasonably be expected to execute repairs or assist in installing plant to collieries, smelting, rolling and pressing machinery-beds and re-lining retorts of furnaces and gas-manufacturing plants or repairing the slipways for ship builders.

The Yorkshire small building firm may have as clients, owners of worsted mills, engineering, tool-making and oil-plant works. The Lancashire builders have clients in engineering, dyeing, bleaching, colliery, glass, cotton spinning and weaving mills. Cheshire builders cater for industries common to that county : acid, alkali, soap and salt plant and works buildings as well as agricultural.

Staffordshire builders are specially versed in their clients' requirements linked with collieries, brick and pottery works. Worcester and Warwick builders have clients with colliery, hardware and jewellery trades to cater for and

to bear in mind in the lay-out of their own premises in plant and equipment.

Industrial firms in the main are not interested in maintaining plant and equipment for labour which they do not employ, but they can and do provide and maintain items of plant, equipment and stocks which are on call for use by the small builders they employ, and who could not be expected to supply.

Special Plant

Sulphur-burners, steel smelting, glass and alkali furnaces and retorts are lined with specially manufactured fire-bricks and silicate brick specialities; the small builder would not expect to hold proprietary specialities, although he would provide labour, plant and equipment required to re-line the special plant retorts and furnaces.

In a similar manner the small builder would undertake the masonry tooling necessary for ensuring a solid and regular bedding to an engine bed or heavy hydraulic press, but he would not be expected to provide the gantry and gear necessary for the removal.

On the other hand, the builder would be expected to find trestles, plants, cradles or other equipment, including brushes, with which to execute an annual operation of lime-whiting throughout a works area to comply with the Home Office Regulations which require such cleaning and repair work to be executed once every 12 months.

It will now be appreciated that builders' lay-outs can in some respects be very similar, especially in items of plant equipment and stores that affect repairs to dwelling houses; and yet be varied in the bulk of the work undertaken, owing to specializing in the work with materials peculiar to the local conditions.

Further, there are the sectional building trades in which the owner of the business is specially interested. It is considered that some 50 per cent of all small builders' businesses have grown from craftsmen skilled in the joinery trade, and in such cases the workshop lay-out with plant, equipment and stocks will be found to tend towards specialization in repair work in that trade. Builders are naturally inclined towards executing work in the trade in which their experience is greatest. A typical small builder's business workshop lay-out is shown in Fig. 1. It is practical and suited to the bulk of those building trades which form the basic groundwork of builders' businesses.

There are districts in Britain where stone is cheap and plentiful; others in which bricks predominate; a few where slates have the prior place, and others in which timber is at hand, while stone, bricks, and slates are costly because of handling, labour and transport. Whichever material is the most plentiful is likely to provide the most labour and skill locally, with a tendency to employ the other necessary trades as subcontractors to the chief one.

Property Maintenance

A general small builder's business which leans towards woodwork and repairs of a general character would build up equipment and stocks to meet repairs and alterations such as sundry repairs and maintenance of estate

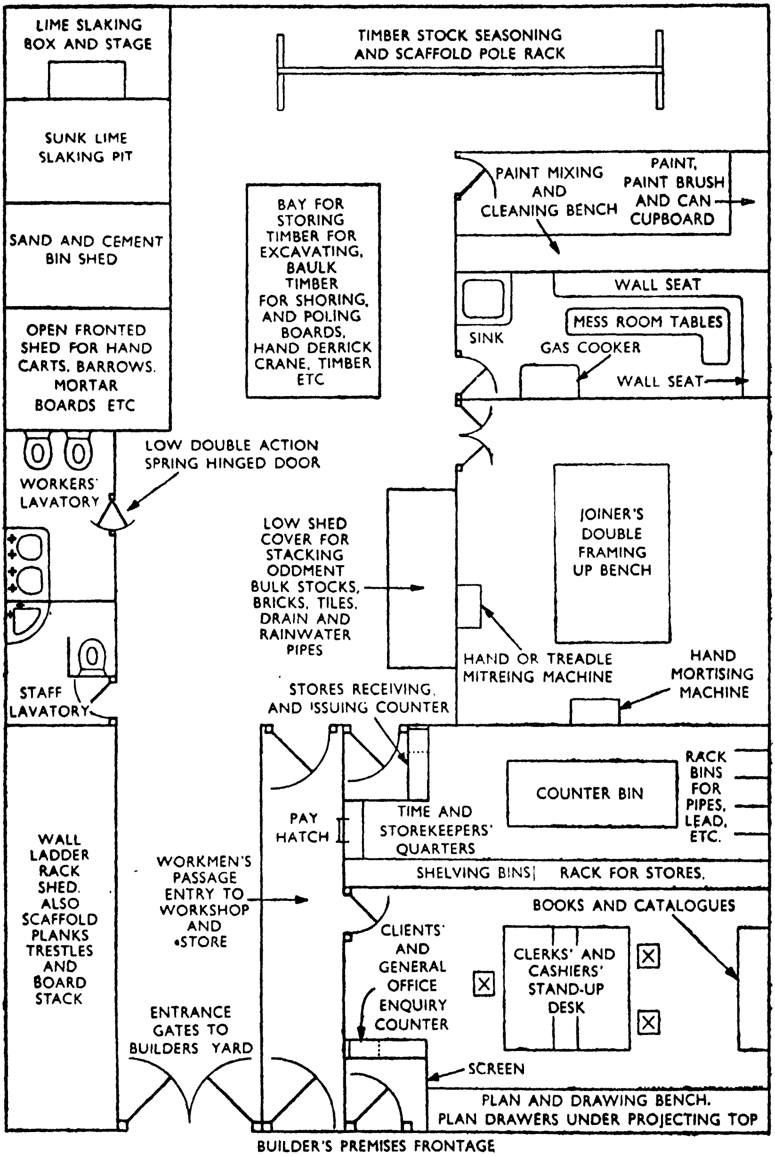


Fig. 1. Lay-out of a typical small builder's yard and workshop. The workshop is well-planned, practical and admirably suited to the bulk of the building trades which form the basic groundwork of a builder's business. The office is at the front and commands a view of the entrance to the yard. Adjoining the office is the store for ironmongery, and behind the store there is a small joiner's shop.

properties, due, perhaps, for external painting and for which it was first necessary to repair such items as defective window sills or sash or casement frames; loose door frames requiring splice pieces near the step level; new eaves, gutters or spouting; new downpipes, with repairs to back-yard and outhouse doors. Other work requiring general plant items for this type of business includes:—

(*a*) Refinements in making the property lay-out more convenient; (*b*) structural defects such as strutting or shoring, under-pinning, and renewal of shop fronts; (*c*) preliminary alterations, additions or modifications; (*d*) revisions to accommodate new Home Office regulations or Local By-Laws; (*e*) removal of defective parts of a building, such as rot in wood floors, and correcting by substitution of some safer or more useful type; (*f*) the making, framing, fixing and striking of boiler firebrick arch centring, or brick staying framework of a concrete pedestal, foundation or base.

These are all typical items of work undertaken and for which varying plant, equipment and stocks are required to meet the various classes of work.

The general class of property maintenance suggests that the joiner is the best qualified of all tradesmen to take the lead as foreman of repair work, and in that capacity to have charge of the plant and equipment that is common to maintenance and upkeep work. Hence the special grouping of plant and equipment under this head, the items of which may be up or down according to repair requirements (Table I).

Plant	Equipment	Stores
Joiner's bench	Glue kettle	Manufactured timber as T. & G. board and block mouldings
,, saw blocks	Adze	Beads and strips
General joinery machinery	Draw knife	Timber oddments:
Band saw	Maul, heavy	Various softwoods
Wood lathes	Mallet	,, hardwoods
Mitring machine	Bars, crow, various	,, plywoods
Hand mortising machine	Nail drawer	,, pulp boards
Cramps, large	Hand saws, rip	Files
,, sash, small	,, ,, cross-cut	Ironmongery:
Extending ladder	,, ,, panel	To suit building
Step ladders, tall	,, ,, tenon	,, repairs
,, ,, short	,, ,, dovetail	Nails, assorted
Scaffolding boards	Plough	Screws, assorted, steel and brass
Saw sharpening chops	Sash fillister	Door furniture
Vice	Chisels, various	Window furniture
Bench screw	Gouges, various	Cupboard furniture
Grindstone	Screwdrivers, various	Hack-saw blades
Sheave blocks	Brace and bits	Stencils
Ropes	Hammers, various	Stamps, letter and figures
Grinding wheel	Priming brushes, paint	Priming, red lead
Plug drills, jumper and morse	Hack-saw frame	Paints, ready mixed
	Padsaw	Varnish

Table I. Special grouping of plant and equipment for joinery and general repairs.

Those with experience of woodworking machinery might consider such items as the adze, plough or sash fillister as out of date, but these are common tools used freely in a builder's shop without power machines. There are plenty of builders executing door, or window-sash frame repairs who, to match existing mouldings, find the use of such tools, including hollows and rounds, a very necessary part of their equipment; even with machinery available it is sometimes far less costly to work short-length repair mouldings in this manner than to set up a moulding machine for the purpose.

The plant, equipment and stocks for a builder's business undertaking painting and decorative work, and drawing on associated businesses to subcontract for trades outside painters' and glaziers' trade work, can be scheduled as shown in Table II.

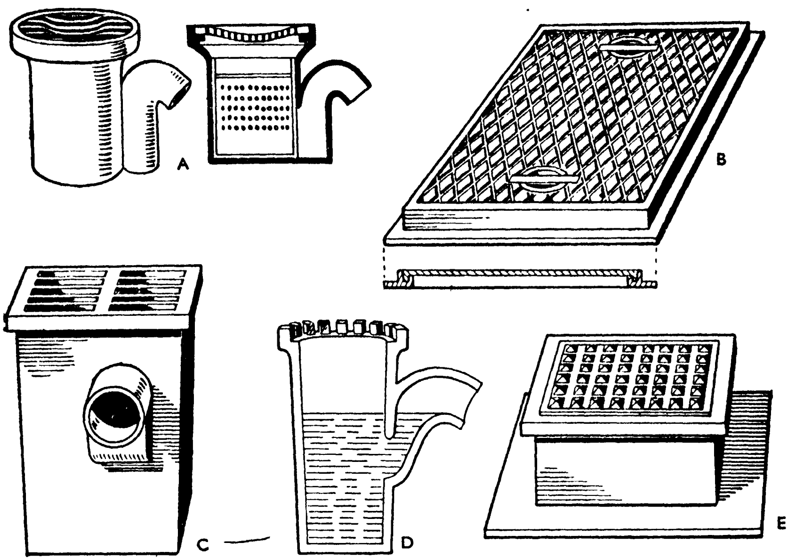
Builders who make painting work a 50 per cent speciality of their business need shop accommodation to receive new joinery parts that require priming or to stack sashes for the necessary period to allow drying of paint or hardening of putty after glazing.

Sanitary Engineering

Builders' business premises executing plumbing and sanitary engineering as a special side build up a group of regular workers who are specially skilled in all kinds of plumbing, pipe work, sanitary fitting and drains, with other employees as subsidiary trade workers. The chief tradesmen are plumbers and sanitary engineers, and the plant, equipment and

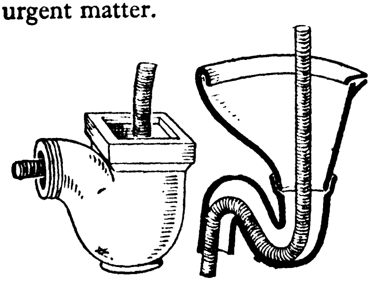
Plant	Equipment	Stocks
Ladders, long	Buckets	Red lead, powder
,, medium	Paint kettles	White lead in oil
,, short	Paint brushes, flat	Mixed paints, various
Step ladders, various	,, ,, fitches	Varnish, outside and inside
Trestles, various	,, ,, wall	Size
Window opening cripple	,, ,, wire	Paste
Hanging cradle	,, ,, duster	Whiting
Sheave blocks and ropes	,, ,, fibre	Plaster
Hanging link shackles	Turks head	Alabastine
Scaffold boards or planks	Sweeping	Steel wool
Trestles, tall and short	Sponges	Pumice stone
Splicing ropes	Leathers	Paint pickle
Wire lashings	Putty knives	Soaps, dry and block
Scaffold poles	Scissors	Soda
Outrigger tackle with anchorage	Scrapers	Glass paper
Dust sheets	Screwdrivers	Linseed oil, raw
Tarpaulins	Pincers	,, ,, boiled
Burning-off lamps	Pliers	Turpentine
	Sieves	Putty
	Glass-cutting bench	Vegetable black
	Diamond	Knotting
		Pigments (powder in oil)
		Limestone

Table II. Plant, equipment and stores for painting and decorating work.



Selection of drainage fittings which includes *A.* grease traps; *B.* manhole cover and frame; *C* and *D.* two types of gulley trap; *E.* yard grating and frame.

stocks specially cater for these trades, treating the supplementary labour and conditions as auxiliary to the chief work in the business. Only the most primitive of buildings are void of repair work required to be executed by plumbers, and a feature of repair work of this character is that it is usually requisitioned as a very urgent matter.



Flexible drain cleaner which enables obstructions to be removed without involving the laborious and troublesome task of breaking up the drain.

Burst and frozen water pipes; leaking and defective water storage cisterns; stopped sanitary fittings; blocked drains; waste and soil pipe replacements; leaking sewer gases; defective eaves gutters; roof leakage of lead flats and valleys; faulty flashings and gutter backs, comprise but a few of the services required by clients.

Plant, equipment and stocks for a builder's business on these lines predominate in the suitable items which will be regularly employed and among others those shown in Table III are included in the schedule.

Heating and Ventilating

Heating and ventilating form another line of business that has features lending themselves to include odd workmen in the allied trades which tend towards building trade repairs of a general

Plant	Equipment	Stocks
Plumbers benches	Lead kettle and ladles	Lead, sheet
Vices, jaw	Brazing set	„ black
„ pipe	Breast drill	„ piping
Screwing stock and dies	Blow lamp and pipe	„ composition
Taps for screwing	Ferrett wires	Solder, block
Portable blast for oil	Drain cleaning rods	„ wire
Acetylene welding	Plungers, various	Brass taps, bib, various
Bos'un chair with rope	Bobbins	„ jointing rings.
Platform scales	Mallets, various	Waste traps, various
Pipe racks, vertical	Hammers, various	Ball taps and parts
„ „ horizontal	Chisels	C.I. pipes and fitments:
Casting moulds	Scrapers	Rainwater
Portable smith's hearth	Files	Soil
Scaffolding, various	Rubber boots	Waste
Ladders, stave, various	Trowel	C.I. manhole covers
„ step, various	Lead beaters	Galv. iron piping
Handcart		W.I. gas piping
Barrow		Sanitary fittings:
Truck		W.C. pedestals
		Washhand basins
		Sinks, various
		Baths, various
		Urinals
		Red lead
		Putty, mastic
		Paint for joints

Table III. Plant, equipment and stores for plumbing and sanitary engineering.

nature while maintaining a basic heating and ventilating character. Small builders of this type undertake repairs to domestic hot water systems in all types of buildings, as well as to heating and ventilating plants of cinemas, churches, flats, offices, and other similar types of building.

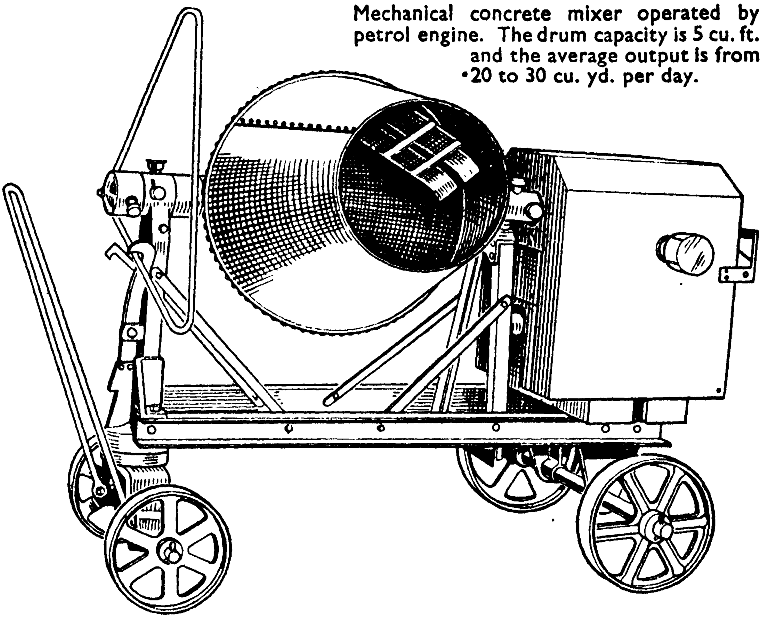
Upkeep of Plant

Heating and ventilation plants include many items that require upkeep, overhaul, repair and general attention. Solid fuel-fed boilers, liquid fuel, gas fuel, electric energy fuel vary the equipment, tools and stores housed and used in upkeep. The items of plant which are given in Table IV may be submitted as typical and essential requirements for domestic hot water, steam-heating and ventilating plant maintenance.

The plant, equipment and stores for the small builders who make their chief speciality repairs and alterations to stone work (Table V), executing replacements and repairs to such building features as decayed ashlar blocks, and stone cornices and parapets, draw on yet other types of plant, equipment and stores. These are often of the same character, but supplied in much heavier types as instanced in a carpenter's saw-block or stool compared with a similar framing which is generally known in the trade as a mason's banker.

Bricklaying

The builder's business that employs bricklayers and labourers as the basic trade of a small builder's business executes the work required by clients on the



Mechanical concrete mixer operated by petrol engine. The drum capacity is 5 cu. ft. and the average output is from •20 to 30 cu. yd. per day.

site of operations rather than at the builder's yard, and in such cases the bulk stores like bricks, cement, mortar, occupy accommodation that in other businesses would be allocated to process repair trades.

Plant	Equipment and Tools	Material Stock
Workshop bench	Hammers, assorted	Bolts and nuts, assorted
Power grindstone	Spanners, assorted	Valves and stop cocks, assorted
,, emery wheel	Files, assorted	Springs, assorted
,, metal saw	Stock and dies, assorted	Packing, assorted
,, lathe	Drills, assorted	Conduits, assorted
,, drilling machine	Chisels, assorted	Steam, gas, water pipe fittings
Boiler testing and other pumps	Drifts, assorted	Elbows, bends, couplings, tees, etc.
Lifting jacks	Pipe grips, assorted	Joint rings, assorted, as manhole, mudhole, etc.
Chain block and ropes	Pipe cutters, assorted	Welding wire
Baulks or planks	Turning tools, assorted	,, spelter
Acetylene welding plant, mounted on portable bogie	Hack and other saws	Red and black lead
Portable pumps	Pliers, assorted	Graphite
,, smith's hearth	Lifting crow bars	Fuel and oils
,, anvil	Cupboards and drawers for tools, salvage	Wiper rags, etc.
Pipe and metal racks	Duplicate parts	Paints, various
Bogies, various	Packing and jointing oddments	
Rollers, various		

Table IV. Typical details of the plant, equipment, tools and stock which are essential for heating and ventilating plant maintenance.

Plant	Equipment	Stores
Chain lifting block	Lifting lewises, various strengths	Portland stone, block
Block and ropes	Stone dogs	,, ,, sawn
Snatch block	Stone grips	Grit stone, rough
Winch	Stone bus frame	,, ,, sawn
Mason's banker	Large compasses	Step rock sawn
Setting-out benches	Plumb rule and bob	Slate sawn slabs
Hand derrick crane	Straight-edge, steel	,, dowels
Shear legs	,, wood	Copper dowels
Guide ropes	Drawing boards	,, cramps
Packing timbers	Zinc cutters	Stone saw-blades
Poles, various	Spalling hammer	Carborundum
Scaffolding, various	Rule	Zinc for moulds
Ladders, various	Steel squares	Paper rolls (strong)
Mortar boards	Chisels, various	Hydraulic lime
Blue print machine and lamp	Gauges, various	Plaster
Heavy crow and pinch bars	Boasters, various	Sand
Small forge	Hammers, various	Fat lime
Anvil	Mason's mallets	Slurry
Cooling tank	Level	Paving stones
Smith's tool sharpening equipment	Fixing bedding and pointing trowels	Flags for footpaths
		Kerb stones
		Channel stones

Table V. Essential plant, equipment and stores employed in masonry repairs.

The working shop in that case is turned on to cutting and rubbing down sand arch bricks and wall tiling.

For such items of work as dismantling stoves, ranges, boilers, with replacement of seatings for domestic-range back-boilers or other burnt-out parts; repairs to concrete, brick, tile, cement-finished or slab floors; alterations and repairs to defective earthenware drains and manholes; cutting away and perforations through brick or concrete walls; drilling and cutting for holding down bolts, shafting hangers and brackets to sanitary fittings and domestic washing boilers, etc., the plant equipment and stocks required would be as in Table VI.

Slating and Tiling

Small builders have frequently to undertake repairs for slating and tiling work. Some of the plant is common to other repair-trade services, but there are items of plant, equipment, and stores peculiar to the repair work in these classes.

Repairs are not wholly confined to roofing slates or roofing tiles. There are many business firms which draw on small builders for repairs to process vats, i.e., slate brine vats, slate tables, shelving for cold stores, urinal divisions and wall slabs, sinks and cisterns. Cutting, grooving, drilling, jointing and polishing—all range within the scope of work which the small builder may be called upon to do, and which are often associated with the stone masonry section of the small builder's business.

Plant. For roof repairs in slating or tiling: draw-on ladders, cripples, and scaffolding common to other builders' plant, with the exception of the slate nail-hole perforator.

Equipment. This is very simple in character and consists of a slater's claw hammer, nail-drawing knife, slate-cutting knife and trowel for bedding and torching underslates.

Stores. Slates, standard oddments. Tiles, standard oddments with hip, valley and ridge patterns; lias lime, mortar, hair, cement and sand.

Plastering Repairs

Plastering maintenance repairs are not always included in the direct items of work executed by a small builder's business, but as repairs are often confined to settlement cracks or loose plaster patches, minor repair work is often undertaken by painters or other workmen handy in the use of plant equipment and stores used by the plastering trade. Such jobs as correcting dampness by rendering, and pebble-dash finishing the outside walls of buildings, however, are generally put out to subcontract.

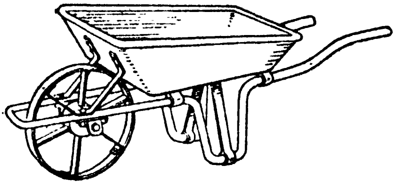
Plain plastering is a finishing medium whether it is applied to wall or ceiling, and as inside work it is modest in plant, equipment and stores. Repair work in this class must of necessity be undertaken on the actual building site. Repairs to external pebble-dashed walls are also site work.

The chief materials used in plastering repair work are common to all small builders' stores. Sand, lime, plaster, hair, water and cement are the chief ingredients, and for repair work these are available at most builders' yards or can be readily delivered by builders' merchants on the site.

Fibrous plaster repairs involve

Plant	Equipment	Stocks
Scaffolding and all parts Ladders, stave ,, step Trestles, various Roof cripples Ladder plank Scaffold brackets Mortar boards Buckets Cutting and rubber bench Brick hods Mortar barrows Brick barrows Brick skips Flat topped bogies Runway planks or scaffold boards Centres for arches	Trowels, large ,, pointing ,, small ,, float Hammers, lump ,, medium ,, tiling Chisels, long ,, short ,, fine for wall tiling ,, bolster Drills, pipe ,, diamond ,, rose Skivit and lines Rule, 2 or 3 ft. Monkey wrench, adjustable Screwdrivers	Common bricks Facing bricks Sand bricks Fire bricks Staffs. Blue bricks Arch bricks Curved and bullnosed bricks Splayed bricks Fire clay Cement Silicate Sand Plaster Spare tiles: Wall Floor Fireplace Crushed granite Crushed ballast: Stone Brick Salt glazed drain pipes White glazed manhole half-channels Step irons

Table VI. Plant and equipment necessary for bricklaying and boiler repairs.



Builder's all-steel barrow. It has a pressed steel body, steel tubular handles and a 16-in. steel wheel.

a workshop lay-out at the builder's depot for pattern making, casting and drying-off the soft casting members, or plaque mouldings ready for transport to buildings under repair. Typical requirements are given in Table VII.

During the execution of repairs to property it is frequently necessary to renew existing cable or electric wire service runs and fittings (lighting, power or cooking) or to add additional circuit boards and plug points. In many areas, work of this nature is executed by workmen directly employed by the electric supply company, but the alterations are negotiated through the builder, who supplies all the labour necessary. In cases where the builder employs electricians, special plant, equipment and stores are necessary.

Electrical Maintenance

In electric lighting over an industrial works area, the electrician would have maintenance plant available from a works rather than from a special builder's plant store. In a block of offices, or flats, the service cable would enter the building from an underground position, in which case all work undertaken in maintenance would be, therefore, of a purely internal character.

Electrical upkeep and running repairs are much more safely executed internally with dry conditions than in the open air. The plant peculiar to the electrician has a greater similarity to builders' plant than that used by engineers. The energy is not generated on the spot, but brought to the building ready to be connected by cables and wires and conveyed to the power or lighting service

Plant	Equipment	Stores
Benches:	Floating trowels, steel	Lime
Moulding length	,, ,, wood	Plaster of Paris, Keene's cement, etc.
Casting length	Pointing trowels	Scrim
Pattern moulding	Rules	Scantling timbers
Plaster stands	Moulding horses	Casting jelly
,, boards	Derby screeding tool	,, wax
Drying shed	Hods	Laths, cloven
Farm boiler, copper pattern	Spades	,, sawn
Step ladders	Trammels	Lath nails
Trestles	Mixing bowls	Galvanised flat-headed nails
Planks or scaffold	Straight edges	Plaster partition:
	Plumb, bob and line	Blocks
	Scrapers	Boards
		Ox hair
		Cement, white
		,, Portland

Table VII. Necessary plant, equipment and stores for plastering repairs.

Plant	Equipment and Tools	Stores
Workshop bench Hand drilling machine Portable cutting and screwing bench Bench with pipe vice Conduit bending blocks Charging boards Step ladders, various Extending stave ladder Portable working bench ,, scaffolding Testing apparatus: Meggo cell volt-meter A.C. test set Illumination meter	Pliers, various Screw drivers, various Chisels, various Hammers, various Hack saw frame Ferret wires Callipers Stocks and dies Tap wrenches Drills, various Breast drill Portable lamp and leads Torches Rawl plugs Drills	Electric light bulbs Cable, assorted Conduit, assorted Switches and fitments, assorted Clips, assorted Fuse wire, assorted Files, assorted Distilled water Acid Oils, various Cleaning utensils and materials Hack-saws

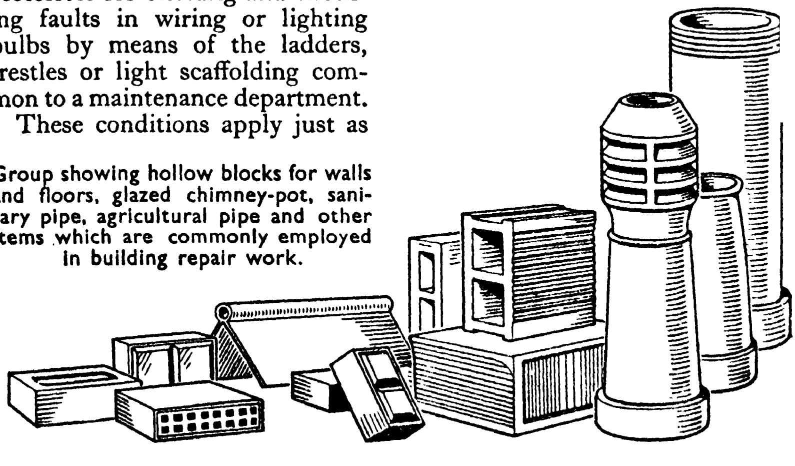
Table VIII. Equipment for the execution of electrical repairs and maintenance.

points. The distribution is via the main switch boards, whether for power or lighting, and from these positions through the distribution and circuit boards to the electric energy consumption units.

The heavy plant housed by the heating department should always be at the service of the electrician for the removal of a burnt-out motor, or the changing over of frayed or defective lift-cage wire ropes. Plug power points are often in the skirting height; while wall bracket and ceiling-light positions are accessible for cleaning and checking faults in wiring or lighting bulbs by means of the ladders, trestles or light scaffolding common to a maintenance department.

These conditions apply just as readily to the more important public and semi-public buildings. Typical plant, equipment and stocks for this sectional maintenance work are given in Table VIII.

Telescoping staging is a type of scaffolding frequently used by electricians for elevated bracket or doorway entrance soffit lighting points but its height and the width of the framed steadying base are often too bulky to pass through the doorway openings; hence the need for a portable unit that can be stored away in small compass.



Group showing hollow blocks for walls and floors, glazed chimney-pot, sanitary pipe, agricultural pipe and other items which are commonly employed in building repair work.

CHAPTER 16

BUILDING MAINTENANCE

GENERAL UPKEEP. INSURANCE. OUTLINE OF ROUTINE. MAINTENANCE STAFFS. CLEANING FAÇADES. INTERNAL DECORATION. SANITATION. HEATING AND VENTILATING. JOINERY AND PAINTING. WOMEN CLEANERS' WORK. WALL AND FLOOR FINISHES. FLOOR POLISHING. CARE OF UPHOLSTERY. CARPETS AND CURTAINS. DUTIES OF ENGINEER'S DEPARTMENT. ELECTRICAL MAINTENANCE. CANTEEN SERVICE. TIMEKEEPER AND NIGHT-WATCHMAN.

MAINTENANCE of property means looking well after the upkeep of the fabric and of the parts comprising the whole, to ensure a fair life of service for each one of those parts. Some parts are subject to more wear and tear than others. An entrance step, or a workshop floor by the side of a bench, in constant use will soon reveal worn parts; while a leather-upholstered chair or fixed seat does not depreciate while in use at anything like the rate that it does when sheet-covered in storage.

Any building of character, as, for instance, a town hall, a secondary school or a block of offices, employs directly, during erection, some fifty crafts, trades or special items of labour and materials; and that number does not take into account the furnishings and fittings.

The work undertaken by the bricklayers, stonemasons, joiners, slaters, plasterers, painters and polishers may compare in cost with many other parts of the building, but it does not follow that there will be a heavy cost in upkeep charges. Well-preserved buildings with these component parts are quite common with a 200–300 years' life, but service parts such as steam boilers or electrical plant equipment carry a 5 per cent yearly depreciation charge that allows for their replacement after a 20-year period. By that time the repair charges and dislocation of service may not warrant further patching repairs.

Onus of Maintenance

Maintenance of any building is generally the responsibility of the owner, but letting on lease terms for a period of years often includes a division of the responsibility. The owner accepts liability for keeping the property wind and rain proof, but inserts in the conditions of the agreement clauses that place the onus of maintenance in all other respects on the tenant. At the close of his term of tenancy the latter must leave the premises in as good condition as they were when originally taken over.

In actual fact maintenance starts when the first length of a building foundation is inserted, but not usually at the owner's

risk. It is custom and practice to put the onus of upkeep on the builder, both during construction and for twelve months after completion.

During construction a careless workman may leave a coke fire burning, or drop a lighted cigarette, thus causing fire and damage. The owner would, therefore, claim reinstatement at the builder's expense. A claim would be equally valid if constructional defects appeared from faulty work.

This chapter is especially concerned with the owner's responsibilities and, indeed, in many cases liabilities; for where the public have access to or are in the vicinity of a building, they must be kept free from danger of every kind. A fall through a mat slipping on a polished floor may involve an owner in a claim for damages which would be just as great as those involved in a case of injury sustained by a third party through a falling gutter, roof slate or stone cornice.

Insurance

Building maintenance raises the question of insurance against fire, water, flood, lightning, damage by aircraft and third-party claims, and it should be appreciated that insurance for an amount less than the full value means that the owner carries the proportionate balance risk. Building contents, whether furniture, stock, plant or machinery, may be separately insured, and in the case of steam boilers and power plant, insurance to cover breakdown risks is also advisable.

H.M. Factory regulations, and Accident Register and Notices, belong to maintenance; and Workmen's Compensation is a further matter not to be overlooked where steam or power plant and machines are employed. H.M. Inspector of Factories can claim to be shown the report of the insurance company's engineer, while the insurance company's conditions claim full liberty of inspection of passenger and other lifts. Insurance companies protect themselves against breakdown claims by means of regular inspections, and by calling the attention of their clients to weaknesses, undue wear and tear, worn out parts, insufficient lubrication, thin boiler plates, and leaking tubes.

Compulsory Repairs

After report all defects must be corrected, otherwise the risk is transferred from the company to the client, and that risk may be criminal as well as financial.

Cleaning, overhauling, repairs and replacements in all such matters are maintenance items of a semi-compulsory type; whereas the decay of stone or brick façades, the wet or dry rotting of timber framing, the corrosion-pitting of iron casements and furniture are items of maintenance at the option of the owner's will or pleasure. However, should the delay in repair develop into a nuisance, menace or danger to the public, the borough surveyor or district medical officer can claim to have the necessary work carried out.

Outline of Routine

Building maintenance work cannot be dealt with in bulk, but it can be visualized in its sectional parts. Foundations are vital parts of all buildings, for when they are adequate in superstructure load spread, free from dampness and tree roots, ventilated and

free from ground gases, they are a priceless asset. On the other hand, when the ground is unstable, or unevenly loaded, there is no limit to the extent of the maintenance repair work to which every part of the building becomes subject.

Defects which require correction may not only involve excavation and underpinning, but include damp courses, external and internal walls, window openings, sill arches, wall and ceiling plasters, floor defects, roof leakage, and dropped and tight-fitting doors. Building fabric repairs of this type are abnormal in character and have to be corrected by experienced workers rather than the usual maintenance staff.

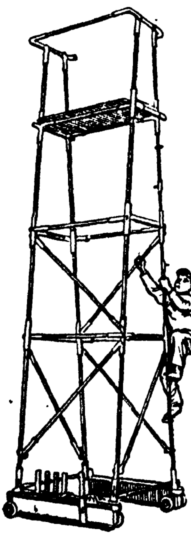
Superstructure

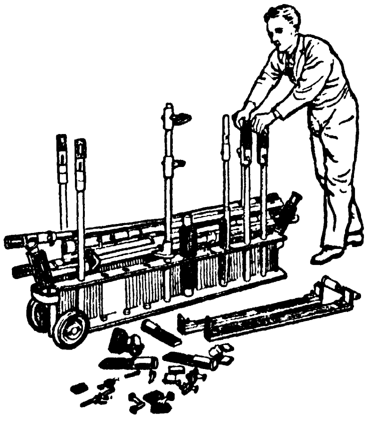
Starting at ground level, external walls of wood, brick or stone are subject to decay at just above ground level, especially where splashing from some overhead eaves or similar projection exists.

Marble and limestone plinths and bases are specially subject to repair claims when adjoining public thoroughfares. Roof-coverings, whether of slates, tiles, asphalt, zinc, lead or copper, are all liable to defects, for none of these materials can be described as more than semi-permanent. The natural conditions of sun, wind, dry and wet periods, snow and frost, to say nothing of atmospheric conditions in some cities and towns, all play their part in fixing the limit to their durability and length of life.

Window and door finishings, external and internal, whether of wood, iron or bronze, cannot be left to serve and function without maintenance.

External pavings and internal floors may be executed with the greatest care and with the best materials, but, without mainten-





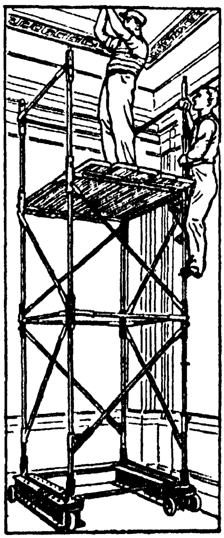


Fig. 1. Single bogie mobile tower which can be readily assembled indoors as shown. It is used for a large variety of purposes, among which are included the cleaning and repair of cornice fittings and electrical and gas fittings.

ance, depreciation would be rapid and repairs costly.

Finishings in painted or polished woods, sanitary fittings, drains, domestic hot and cold water supplies, gas and electrical services, cooking and heating equipment, also require regular upkeep service.

The governing factor in determining the nature of the upkeep labour to be employed varies with the property to be maintained, but it is certain that, quite apart from the regularly employed cleaners, group craftsmen will have to be employed to maintain the fabric of the building at intervals. Firms that are large enough to require a "works department" embracing several trades usually employ a building manager or works superintendent, to take charge of all administration connected with plant, fittings, material and labour for building upkeep.

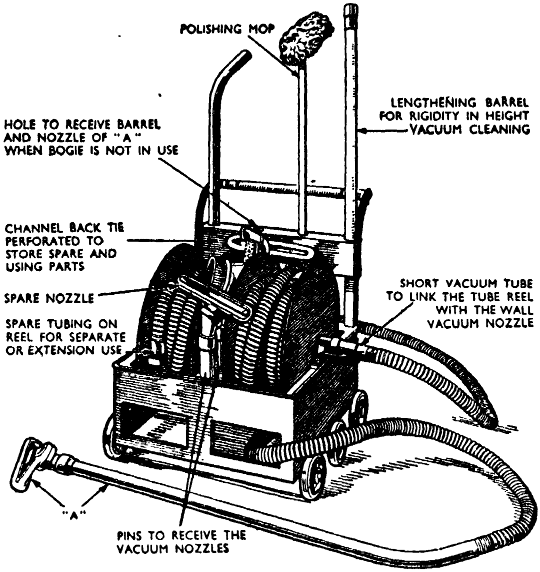


Fig. 2. In the maintenance of carpets and upholstery the vacuum cleaner is a most important factor. A portable unit for use in buildings is shown above, together with details of the individual parts of the cleaner.

Fig. 1 illustrates a typical portable scaffold which can be assembled and used in large rooms served by single door openings.

In cases where the size of the property does not justify the employment of regular labour, a local builder is usually employed to execute the essential overhaul and repair work.

Maintenance of a building includes amongst other repairs the periodic cleaning of the façade. Stone-faced buildings collect sooty deposits on their protected facets, while the exposed portions facing the prevailing winds and rain retain a semi-clean appearance. Stonework preservation calls very definitely for the periodic removal of sooty deposits by washing or steaming.

Method of Presentation

The Building Research Station, after examining various methods, continues to recommend that stone ashlar be washed down with a plentiful supply of water and a scrubbing brush. Glazed bricks and faience façades present a semi-impervious face to atmospheric conditions and in consequence they respond much more readily to this form of treatment.

Fig. 3. Another popular type of vacuum cleaner which is extensively employed for general maintenance work in large offices, public buildings and service flats.

Plain brick façades may also be cleaned down by washing but the more common practice usually adopted is raking out the mortar joints and repointing the brick-work joints, following on with rubbing brick treatment and lining with jointer and straight-edge. Washing down and burning off of old, blistered and cracked painted work, follow consecutively after façade cleaning, coupled with pointing void joints round door and window frames.

Another preliminary step to external redecoration is to overhaul windows, doors, frames, balustrades, sunblinds and fittings, eaves-gutters, and rain water, soil and waste pipes to ensure that lock, latch, door and window sash cords and window casement furniture are intact and in good working condition. In this way the correction of defects after redecoration has taken place is avoided. The latter are repair features that can proceed at the same time as the cleaning down of the façade, leaving until completion the washing down, the bricking up and renewal of all parts painted previously.

Internal Decoration

Maintenance work for internal decoration should in all cases be subject to the prior overhaul repair of fittings, fitments and furniture, it being equally important to execute throughout the whole property such repairs and adjustments as may be necessary.

Internal decoration inevitably disorganizes business, and for that reason it is advisable to prepare a plan of action which will incur the minimum business disorder and upset. Chimneys, if in use, require sweeping at least once a year. Fireplaces, fire-backs, surrounds, tiled hearths, ranges, stoves, domestic hot-water boilers and coppers, all occasionally require repairs, and the most fitting time to arrange for the overhaul is during the period preliminary to internal decorations or during the spring-cleaning period.

Vacuum cleaning plant is installed in many buildings for maintenance and portable units like Fig. 2 for works or Fig. 3 for offices are useful items of plant.

Water Supply

Water supply and storage vessels for hot and cold water with their services, and flow-and-return pipes, are subject to pitting by soft water and to furring troubles with hard water; hence the need to engage the plumber's services in overhaul and test.

Water storage cisterns are usually placed in the highest point of a building to provide a fair head of water at the draw-off positions, and a weak or leaking storage tank would very soon damage newly decorated walls and ceilings.

Sanitary fittings are another feature of maintenance, which require the periodic attention of the plumber for upkeep and repair, especially in cases where wash basins or W.C. pedestals have been subjected to previous repairs. Spring-controlled bib taps also require regular attention. Maintenance includes the smallest matters which aim at cleanliness and convenience as well as the use of marketable products. Fig. 4 illustrates a toilet-roll holder which saves waste by keeping the roll weighted to the wall and provides a receptacle for cigarettes and light articles.

Electric light and power installations, pendants, fittings, bulbs, shades (see Fig. 1), wiring, fuses, plugs, switches, together with power motors, lifts, pumps, fans and main switches, are all items that call for regular maintenance, some of which must be independently inspected and on which reports must be furnished in order to conform with Home Office regulations and insurance company conditions. All require maintenance attention prior to internal decoration.

Heating and ventilating installations comprise other items of a similar nature such as supply cisterns, pipes, traps and similar parts outside the boiler-house area

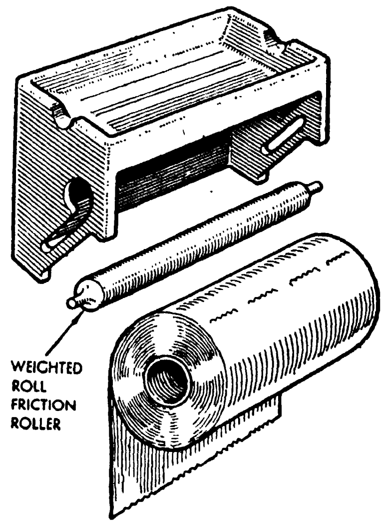


Fig. 4. Combined ash-tray and toilet-roll holder. The simple but effective design keeps the roll weighted to the wall, thus avoiding waste of paper.

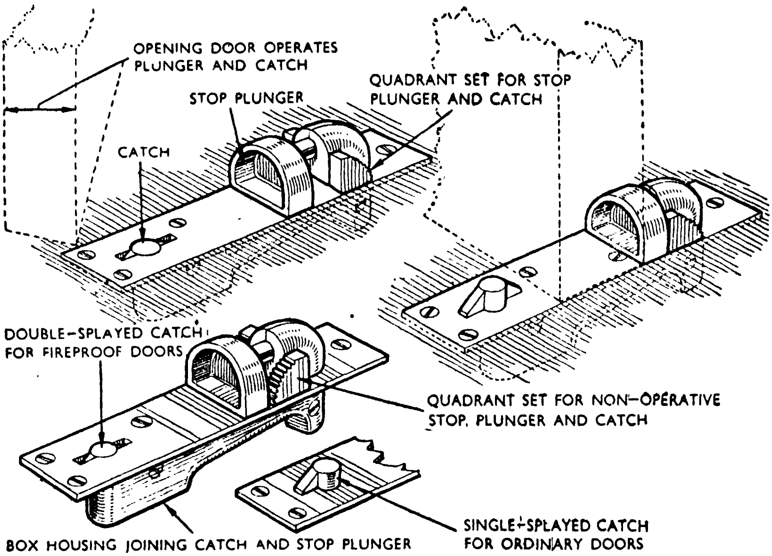


Fig. 5. Useful and ingenious door stop. This stop is particularly valuable in the case of strongly-sprung double doors in public buildings and can be set in various positions as shown. The stop has a special double splayed catch for holding fireproof doors so that they cannot be accidently opened in case of fire.

which are the better for maintenance attention during spring cleaning or prior to re-decoration work.

The correct time to open up and examine heating plant such as steam boilers, calorifiers, pumps, valves and to wash out, flush and check the heating system, is between May and October. The labour employed for seven months of the year on providing and attending to fires and running repairs is then available to undertake a general overhaul and replacement of worn-out parts. It is during the same period that steam boilers are drained off and opened up for thorough cleaning and inspection, the latter of which includes a thorough examination and testing by the boiler insurance company's inspector.

The void heating period of the summer months allows time for leaking boiler tubes to be replaced or recaulked, for the replacement of defective fire-box brickwork, and for the repair of leaky sections. The boiler flues, being cooled off, are fit for entry and for sweeping and removing the flue dust.

It should be appreciated, however, that the five months of summer void for overhaul and repair of boiler and steam plant only applies to heating apparatus. Week-end and holiday periods have to be encroached upon for maintenance and running repairs to boiler installations which supply steam for those industrial installations which are in use all the year round for power or drying process work.

An outline of maintenance work would be incomplete without some brief reference to joinery,

painting, polishing, marble, upholstery and cleaning work. A good joiner engaged as a regular maintenance officer is a valuable asset for all classes of maintenance work. His early training with its range of differing services specially qualifies him for all kinds of repair work to doors and windows with their frames, floors, panelling, furniture and very frequently latch and lock spring repairs, springs and spring hinges, as well as door stops, of which Fig. 5 is a good example.

Paintwork and Upholstery

Painters engaged on regular maintenance duties have their work plotted to suit the building or business. Washing down painted walls, re-whitening ceilings, making good and touching-up work can usually be arranged to fit in with internal sectional areas of the building during inclement weather; while giving preference to external washing down and re-painting work during the spring and summer months.

French polishing maintenance work is similar to that of the joiner, and includes not only polished doors, skirtings and panelling, but furniture in addition.

The upholsterer undertakes the care of stair and other carpets, moquette and skin-covered furniture, tapestries, screens and the cleaning and repair of fabrics generally.

Window cleaning, because of its intermittent character, is frequently contracted for outside the maintenance labour group. Apart from the foregoing, which comprises a general survey of building sections which require the oversight and labour of male workers, there are daily or weekly cleaning duties which are allocated to women cleaners whose work is of a recurring character and in the nature of:—

Daily washing of entrance steps, hall and public spaces; daily cleaning of stairs, corridors, offices, shop or warehouse working areas; daily dusting of all desks, counters, furniture and room fitments generally; daily vacuum sweeping of carpets, rooms, stairs, and offices (see Figs. 2 and 3); cleaning floor coverings of lino, rubber, marble, board, wood block or marquetry areas; cleaning and flushing sanitary ware fitments; cleaning taps, door handles, window fastenings; sweeping frontages, courtyards and light-hatch areas; cleaning internal glass panels of doors, office and room screens to floor reaching level.

Treatment of Paintwork

The treatment for cleaning painted walls and fitments varies with their position. External work, especially in town and city areas, is subjected to conditions, such as dirt- and chemical-laden atmospheres, which affect the painted surfaces and charge them with grime which becomes embedded in the body of the paint cover, and requires a strong mixture of painters' washing pickle to remove it.

The caustic parts of such pickle have a tendency to disintegrate the weathering surface of the paint; and unless the surfaces being cleaned have been treated with lead base paint, the subsequent weathering properties will be seriously impaired. External painted surfaces are not, therefore, expected to resist atmospheric conditions to anything like the same degree after washing applica-

tions, unless they are treated with an outside copal varnish coating.

The number of times that internal painted surfaces can be washed varies with the cleaning attention and finish. When projections and sinkings are regularly vacuumed as in Fig. 6, the life is increased. A hard gloss enamel finish will resist dirt and grime initially, and practically equals varnished coated work, during washing operations. The semi-gloss or egg-shell gloss finish resists to a lesser degree, while the "matt" finished surface has less resistance.

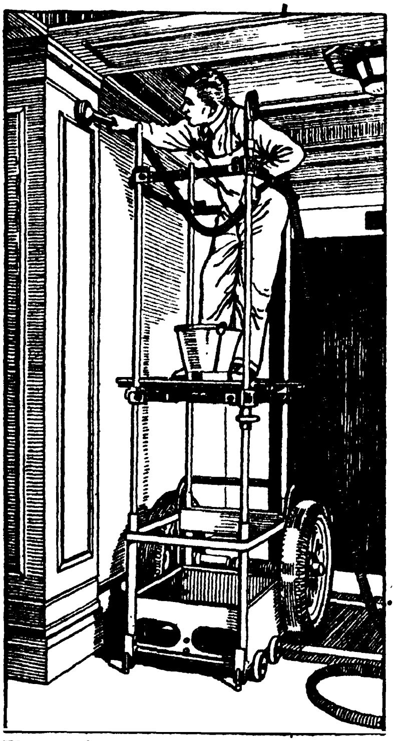


Fig. 6. If projections and sinkings are frequently vacuumed they can also be washed more frequently, thus maintaining the original freshness of the surfaces for a much longer period than would otherwise be possible.

Wallpaper cleaning methods must be adapted to the quality and kind of paper to be cleaned. Lincrusta pulp papers finished with a painted surface may be treated in the same manner as a painted plastered wall, but in other varieties a damp cloth may be too severe on thin paper. The alkali in the lime of the wall plaster to which the paper serves as a decorative feature may have acted on the colours and caused them to fade or cloud. Dry cleaning with soft stale bread is a method worth trying out on some small unimportant patch before treatment of the full surface is commenced. Chemical cleaners are not recommended.

Marble Surfaces

Polished marble features used in building decorations mellow in colour with long exposure, and they should be allowed to retain the softened, artistic appearance which age creates.

Cleaning is executed simply by sponging with warm water and removing the dust and dirt from undercut carving features with the aid of a pointed wooden skewer under a cleaning rag. Plain marble can be cleaned down with a rag damped with methylated spirit or weakened turpentine spirit, and afterwards rewaxed and polished.

Marble depreciation is often seen on the underside of marble mantelpiece shelves, due to the heat from a fire grate immediately behind, or over a radiator on a marble-lined wall; and both positions require regular care and attention to prevent calcining in the first place and marble crazing in the second.

Marble floor slabs, margins and tiles should be kept free from

soapy or greasy surfaces because of the danger of slipping. The latter remark does not apply to quartzite, that splendid natural non-slip marble, so very suitable for paving hotel and restaurant kitchen floors. Cleaning mediums for marble floor coverings should include a small quantity of abrasive powder in their composition.

When marble floors show a tendency to powder, it is a good practice occasionally to use soft soap during the cleaning process so as to feed the marble surface. On the other hand, when the surface of a marble floor shows a tendency to a fatty or greasy surface, it is a clear indication that too much soap and too little rinsing water are being used during the cleaning stage.

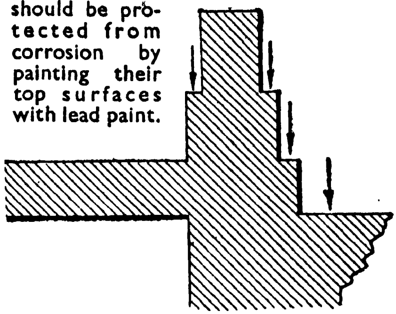
Synthetic Finishes

Synthetic marble finishings, such as rendered walls to staircases and cloakroom and lavatory areas, may be cleaned in the same manner as marble, with the exception that spirit should not be used as a cleaning medium unless the colouring used in mixing the cement and marble aggregate is a natural and fast colour.

Great care is necessary in washing and cleaning synthetic marble wall linings that have had colouring pigments included in the original liquid mixing with the marble chippings. Ceramic and similar vitreous floor coverings, owing to their glassy, hard nature, are practically non-absorbent, and can be subjected to washing process common to red, blue or other earthenware floor tiles.

Glazed brick external walls, and internal dado finishings, require plenty of water, and when thoroughly free from dirt they should

Fig. 7. Copings and other exposed members should be protected from corrosion by painting their top surfaces with lead paint.



be finished off with a clean leather to ensure freedom from brush or moisture streaks when the drying process is complete.

Synthetic stone, being chiefly manufactured with Portland cement as the basic binding medium, will often respond in cleaning to the application of a thick-set stiff brush on the south elevations, and to a spray of water and a stiff brushing on other elevations. Climatic conditions all play their part in corroding soft ashlar sills, copings and projecting or exposed members generally, and the best protection is to apply three coats of good lead paint of the same colour as the stone itself to the top edge of all such projections (see Fig. 7). This will serve as an impervious film preventing the action of rain, snow and frost beyond the exposed surfaces of positions like copings to parapet walls, window and door pediments, string courses and similar features.

Floor Finishes

Floor and covering finishes are, or should be, laid to suit the use for which the building or floor is designed. For example, rubber floor covering may be suitable for shops, offices, staircases and corridors to public buildings, but it is

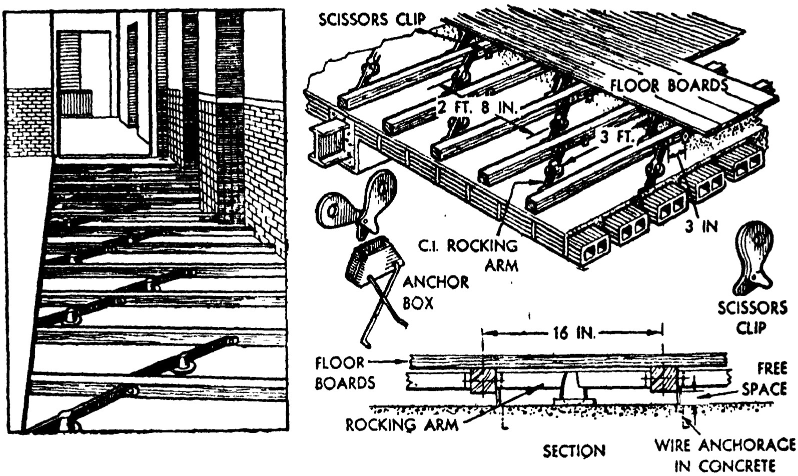


Fig. 8. Roll flex resilient flooring. Floors laid in the manner detailed in this illustration are permanently resilient, and are insulated from wet-rot conditions.

quite unsuitable for rough usage. Factories engaged in the manufacture of soap, sugar and acid require quartzite type floors for grip, acid resistance and freedom from vermin.

The oak block floor has many valuable qualities for some positions, but it is dead, heavy and tiring to the feet of dancers or school children when marching or executing other exercises. It lacks completely the resilience which is common to spring, suspended, or roll flex (see Fig. 8 above) types of flooring.

Treatment of Floors

The reaction to the stone flag flooring of the Lancashire mills was the use of clog footwear; in a similar way cleaning and floor maintenance may be suitable for some types of similar floors. A lavatory floor, for instance, must be cleaned with water, while a floor of similar material but serving quite different purposes would obviously be better if polished.

Jointless floors, concrete, granolithic, magnesite, terrazzo and quartzite, are all floors which require washing during the cleaning process; one exception, however, being magnesite jointless, which, when employed for domestic purposes, may be wax-polished when not subjected to more than ordinary wear.

Concrete and granolithic floors tend to become dusty; and to prevent dust getting into bearings in engine power houses and similar places it is good practice to coat the washed floor with two coats of silicate of soda, allowing each coat a drying-off period of a few hours before use. Terrazzo floors should be treated in the same way as marble and in all positions, such as toilets and lavatories, it is desirable to sprinkle with disinfectant fluid before the final mopping up to ensure the area having a clean healthy odour.

For blue rock flags and steps, soft water should be used wherever

possible, washing with rubbing stone as cleaning medium. Portland and other limestone floors should be washed and scrubbed clean with water and dry soap, and the whiteness kept by sprinkling with pumice powder.

Floor tiles faced with hard film should be treated as Portland stone; if soft faced, soap should only be introduced as a cleaning medium on rough-faced floor tiles and marble like quartzite.

Wood Block Floors

Soft wood blocks are inclined to hold gritty dust in the woody tissues between the annual rings. In schools or similar places it has been found desirable to coat such blocks with an oily stain possessing disinfectant values. By this process dry dust is largely eliminated and in that way sore throat troubles of persons using a room paved with soft blocks are considerably reduced. When stained, sweeping can be executed very effectively with one or other of the sand or saw-dust treated sweeping compounds. Wood-block floors are subject to undue expansion and contraction if treated too freely with water for washing.

For all hardwood block floors a waxed polish surface is advocated. The cleaning of such floors subjected to foot grime and dirt requires the application of a medium which will remove the surface dirt without removing much of the wax. A turpentine cloth kept clean and wiped over the surface of the wax-polished floor will usually remove the dirty marks by serving as a solvent and cleanser in removing the surface dirt, while leaving the surface polish in body, although dulled, much as it was originally, and ready for repolishing immediately the turpentine evaporates.

Periodically it is advisable to clean off the old wax, re-wax and repolish. In that case methylated spirit is a good medium for removing the polish left on the blocks and preparing it for the re-waxing process. Washing off old wax with water is not good for floor blocks, and at the best trying to soften and remove wax by water is a thankless job.

Hardwood plank floors are treated in the same manner as detailed for hardwood block floors. Should the floors at any time become too slippery, wipe over with a clean cloth soaked lightly with methylated spirits.

There are polishing machines on the market for wood and other floors, including one that serves as a vacuum cleaner as well as a polisher. A heated wax spreader is also provided as an extra, or as part of the equipment, to some of the polishing machines. Wax floor polish heated to 50 deg. and sprayed over the floor can be spread much more evenly than it can when spread with a brush spreader after application.

Hand Polishing

Hand-polishing weighted brushes when applied to a waxed surface of a floor do not generate the same heat or distribute the wax as evenly as a polisher which by friction definitely burnishes the face of the wax. It will be understood that soft waxes are inclined to leave a softer and consequently more slippery polish than polishes having a harder and denser body, unless they are applied to an absorbent surface.

Electric floor polishers having a disc polishing unit faced with a

polishing cloth in place of a brush are recommended for this method, as it burnishes floor surfaces to a harder, firmer and less slippery face than is possible with the same machines having a brush unit. The circular motion of a brush on a dirty polished floor will split the caked dirt into many particles and in the burnishing motion there is a tendency to spread the particles of dirt in the direction of the walls or leave a smudgy face.

Linoleum and Rubber

It is not desirable to apply hard wax to linoleum surfaces as the nature of this material calls for an oily wax which will penetrate the body of the lino itself. It is good practice occasionally to allow a lino covered floor to stand with wax spread over its surface, giving the body an opportunity of absorbing the oily ingredients. The process of scraping off and collecting the surface wax and reburnishing or repolishing can then be carried out.

It is advisable to strip off the whole of the wax periodically with methylated spirits, and re-wax as before.

Rubber is specially dense and non-absorbent and great care must be taken to obtain a suitable wax for rubber-covered floors. Wax having a paraffin, petrol or other oil and turpentine base is not recommended, much for the same reason that motor tyres should not be allowed to stand in oil. There are wax floor polishes of a creamy nature on the market which the makers claim are partly water mixed and free from ingredients that harm or soften rubber. Only the thinnest possible wax film should be applied to rubber.

The cleaning of the surface can be executed by a thin swab cloth dipped in methylated spirits. This method is a much easier one than that of washing the rubber once it has been waxed. It is not reasonable to remove the wax from rubber by washing with water, or from any other floor covering once it has been wax treated and burnished. The finest possible spray of wax, after it has been cleaned of dirt or foreign matters is only necessary for the reburnishing process, because rubber is very dense in composition and without absorbent qualities.

A generous use of wax on rubber, even if burnished, leaves a heavy deposit on the surface which has a tendency to become slippery, and as it gets dirty re-treatment will take away the freshness and beauty of the rubber markings.

The cleaning and treating of skin covered chairs varies with the material. Split skins are easier to clean and polish with wax than Moroccos or roans that carry on their face the original hair root pores, but they lack appearance and finish.

The tendency in cleaning with the finest wax polishes is to leave some of the wax base during the burnishing process, which is inclined to dry out white. In such cases it is desirable to have a wax (not cream) polish mixed slightly coloured, to suit the skins which are to be treated, as, say, Kiwi tan, brown, or other suitable shade that can be obtained as a standard material.

Wood Panelling

Polished wood panelling, doors and furniture are further items which require periodic cleaning if the finishings are to retain anything like their original value and freshness. For this work it is

necessary to engage a polisher who will clean, revive and make good bad parts before repolishing.

French and other polishes in course of time sink into the wood or lose their freshness and need reviving on such items as wood panelling, doors, framing and counters. Chairs, desks, cabinets, bookcases, tables and similar furniture and fittings all require to be catered for in cleaning, and reviving and touching-up polished surfaces at intervals to maintain a fair standard of upkeep.

Women cleaners who serve in public or semi-public buildings morning and evening do not usually undertake cleaning work above the level within their reach from the floor, and, therefore, the work of vacuum cleaning or of washing down certain areas subjected to defacement from radiators or similar causes is best left to the qualified painter. Fig. 9 shows a broom saddle, a useful item for housing the equipment of women cleaners.

The cleaning-off by sponging of ceilings where electric light fittings soil the ceiling panels, or where dirt accumulates from rising heat, and also sponging off painted or varnished wall faces, are all items that greatly improve and freshen up the finish of the walls of a well-kept building.

Plumbing repairs in maintenance work are of frequent occurrence and extend far beyond the fixing of tap washers.

The cleaning superintendent's duties, while not extending to outside positions, should include looking after such items as the cleaning out of eaves, gutters, flushing drains and oiling external teak doors and frames.

Maintenance and repair services for heating and ventilation installations have to be planned to meet the requirements of the type of building and plant installed. The Royal Institute of British Architects have, in their London building, set a remarkably good standard in this respect, for their heating plant is one of the most economical in the Capital. The

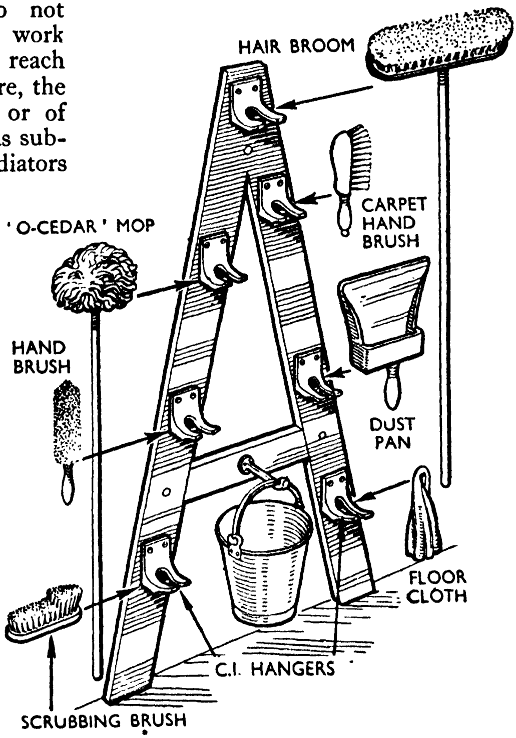


Fig. 9. In the care of brushes and other tools the broom saddle is a very valuable piece of equipment. Each item is allocated its own particular position and it will be noticed that all brushes rest with the bristles facing upwards.

building is heated with low-pressure hot water on the thermal storage principle. Initially the water is heated from cold by electric energy (during the night, or off-peak periods of the electric supply co.) by an immersion heater, which is set in the calorifier.

Electrical Maintenance

Electrical sectional maintenance work includes upkeep and repairs to lighting installations, electric power units, electric clocks, and internal telephone and bell systems. Lighting entails such duties as regular patrol of staircases, corridors, lavatories, entrance halls and similar positions not regularly occupied by workers or staff, to ensure that all electric light points are functioning; as well as to attend to all requisitions of workers who report defective lamps, switches and plugs. Attention must also be given to dusting and cleaning of bronze or chain metal to pendant and bracket lighting fittings, including the washing of globes or glass shades.

Power Units

Power units service maintains all power units installed by keeping the motor, armature and other working parts free from dust. Lubricating grease cups are filled, all working parts oiled and a general inspection is made for noting and reporting weeping joint cable boxes.

Attention and care are given to passenger, goods, and other lifts. The guides and runners are treated regularly with black lead graphite or other special lubricant. All lift-well gears and collapsible closing gates are regularly inspected and oiled, floors cleaned out and all metal work polished.

Working stock oddments are maintained for replacing fuses and wire to required amperes, repairing defective switches, lift floor indicator lights in cage and on lift surround at floor levels.

Cleaning and trade maintenance of intake and switch-room plant are also included, in addition to reading and reporting electric light and power meters and following up any over-normal jump in electricity consumption.

When electric steam boilers are included in plant units the electrician examines the electrodes, and as often as necessary removes coated or pitted electrodes after scraping and cleaning, replacing a standby duplicate set for commission during the cleaning period.

Catering Services

Canteen and mess-room service provides meals, light refreshments and hot water for workers and staff; takes charge of linen, cutlery and pottery; serves, collects and washes crockery, and includes cleaning maintenance of mess room, fittings and lavatory block; locks and unlocks mess-room quarters to coincide with regular mess-room service hours, and reports misuse by workmen remaining after the allotted time.

Storekeeping

Store and timekeeper and first-aid section records details of materials arriving in *Goods Received Book*, with particulars and special note to office of any shortage in advice note quantities, breakages, or other defects, thus enabling the maintenance office to lodge a claim with the suppliers.

Inward materials are checked against order specifications and simple testing measures undertaken where these are applicable.

Inward goods are entered up on Stock Ledger cards and the goods received placed in line and carrying the correct physical stock numbers.

Empty bags, boxes or other costly packages are labelled and arrangements made for their return to suppliers. They are also passed through credit records before payment for goods is due.

Low stocks which are vital for replacement are reported on immediately they approach the minimum quantities.

This section is also responsible for the following: superintending the branding or stamping of new tools or plant before issue; checking the cleaners' cupboards for care of brushes, etc.; reporting damage to stocks or unfair treatment expressed in return tools for replacement; testing electric light lamps before issue and, when in doubt, odd samples at the delivery stages; checking and compiling schedule of bin and store's contents to meet the firm's records at stocktaking periods.

Timekeeping

Timekeeping duties include: obtaining answers to engagement-form record card with applicant's signature and clock number; allocating a clock or tally number to each workman; checking applicants' health and unemployment cards to ensure that they are up-to-date and correctly stamped; maintaining first-aid box and regular supply of equipment; obtaining particulars required by the medical officer or assurance society in cases of accident, and filling in any particulars that the cashier may require for the insurance company. Checking the starting and stopping times of employees; receiving doctors' notes, filing them and advising the cashier's department, so as to ensure that back pay is forwarded each pay day; maintaining the *accident register* record book and having it available at all times for the inspection of H.M. factory inspector.

Duties of Night-watchman

The night-watchman is responsible for the security of the building during the night. He undertakes such work as checking and securing front and back entrance doors, and ensuring that all windows on footpath level are fastened and free from weather troubles.

The watchman also undertakes the patrol of the building at regular intervals; the inspection of fireplaces for dying fires; and the admission or egress, as arranged, of cleaners who take up duty before the staff arrive.

In addition to the foregoing specific duties he assists in a general way with the working of the lift and similar power units, as well as electric lighting requirements, drain and service piping, bib taps, valves to W.P. cistern overflows and drain stoppage during storms.

All messages received during the night are reported in the log book by the watchman, who also collects parcels and letters and reports any form of irregularity such as dripping taps, defective locks, latches, floor spring checks, roof leakages, window opening gear defects and similar oddments requiring maintenance attention. Apart from these items he may also have to report on any special matters, such as wilful damage, that may require investigation.

CHAPTER 17

WAR DAMAGE

BOMB DAMAGE. STRENGTH AND STABILITY OF STRUCTURES. CRACKED WALLS. SLIDING ON DAMPCOURSE. ROOF REPAIRS. REPAIR OF FAÇADES. LATTICE GIRDERS AND ROOF TRUSSES. FILLER JOIST FLOORS. TREATMENT OF CASINGS. REINFORCED-CONCRETE BEAMS AND COLUMNS. FLOORS AND FOUNDATIONS. DAMAGED DRAINS. METHODS OF SHORING. PREVENTION OF SETTLEMENT.

A GLANCE at a blitzed area will reveal the variety of damage caused by aerial bombing. In the case of a direct hit on a brick building the structure is completely demolished and beyond repair. In the case of blast, thin walls of brick or stone have not sufficient tensile strength to withstand it. If the blast is confined, the walls break up completely in a similar manner to those within the detonating range. The sudden shock and intense vibration loosen the bonding materials and the effect of the confined blast is generally a complete collapse of the structure. Where the blast is not confined, and also where buildings are farther away from the falling bomb, the damage is not so severe.

In terraced property, where a complete collapse of structure has occurred, flank walls remaining will need to be shored and the site cleared for future building operations. In those buildings that can be repaired the extent of the damage will vary considerably. Roofs are often largely stripped of their coverings, the slates and tiles piling up at the eaves; brickwork may be cracked and out of plumb; walls may have moved on the dampcourse; ceilings will have fallen; and floor joists will have been partially destroyed.

The effect of bomb damage can, however, be over-estimated. Cracked and bulging walls were quite frequent before the advent of total warfare, and did not cause undue alarm. In the majority of cases the cracks were cut out and repointed and the repairs proved quite satisfactory.

Strength and Stability of Structure. On account of heat insulation and protection from the weather, the walls of domestic property have a great margin of strength to resist the light loads imposed upon them. The structure is further strengthened by the cross walls and the chimney breast. Even when cracked a 9-in. wall still has an ample margin of strength. Severe cracks, however, together with bulging, buckling or walls tilting from the vertical, present a more serious problem. Only a qualified expert can decide what should be demolished and, more important, what is to be retained for repairs. If the wall is badly cracked and bulging or tilting from the vertical, it may be necessary to demolish it. Tie bars passed through the walls at roof- and floor-levels are often used to assist in keeping the walls stable.

Cracked Walls. The interior of the structure must be protected from the weather. Repairs to walls will vary according to the nature and extent of the cracks and the finished appearance that is desired when the repairs have been completed. It is evident from experience of walls that have been badly cracked due to settlement that there is a considerable margin of safety in lightly loaded walls such as in domestic property. Therefore, in walls where there are only a few cracks, and there is no serious displacement, the stability of the structure will not be seriously affected.

War-time Bulletin 21 (published by H.M. Stationery Office) states that the repairs to cracks in faced brickwork should be considered in relation to the porosity of the bricks and type of mortar.

Treatment of Fine Cracks

In dense brickwork, fine cracks of less than $\frac{1}{16}$ in. may be neglected if in sheltered positions, whether they pass through the brickwork or not, but in exposed positions they should be cut out and rebonded with a strong cement-lime mortar mix. A suitable mix would be 1 : 1 : 6.

In porous-faced brickwork in sheltered or exposed positions, whether passing through bricks and mortar or not, a fine crack of this nature can be neglected. Where cracks of $\frac{1}{16}$ in. to $\frac{3}{8}$ in. occur through weak mortar joints, the joints should be raked deeply on both sides and filled with cement-lime mortar not richer than 1 : 3 : 12, cement, lime, sand. In strong mortar joints, the crack should be well cut out and the brickwork rebonded, using 1 : 1 : 6 (cement, lime, sand) mortar.

If the cracks pass through the bricks and mortar, they should be cut out and rebonded, using mortar similar to that existing.

All cracks greater than $\frac{3}{8}$ in. should be cut out and rebonded. If other damage does not necessitate demolition, cracks up to $1\frac{1}{4}$ in. wide may also be dealt with in this way.

Damp Penetration

The different treatment outlined for fine cracks in dense and porous brickwork in exposed positions, is due to the likelihood of damp penetration in the former case. A test for porosity can be carried out by throwing a little water on to the wall. If it is readily absorbed, the brickwork is porous, and there is little likelihood of damp penetration. If,. however, the water runs down the wall without being absorbed, damp penetration is certain. All porous brickwork should be well wetted at the time the repairs are being effected, or the brickwork will absorb the moisture from the mortar. In repairing cracks it is essential to see that good adhesion is secured between the old and new work. Bricks must be clean and free from dust. The mortar must not be skimped and all frogs must be filled, and a good bond secured. A cement-lime mortar should be used, as specified, in preference to one of cement and sand only.

Rendered Walls

When it is necessary to render a cracked wall, the crack should be pointed deeply on both sides. If the brickwork is porous it should be well wetted, and the first coat of cement-mortar applied. This coating should be scored

to leave a key for the finishing coat. Before this is applied the wall should again be well wetted and then the finishing coat applied. Any decorative feature such as pebble-dash or marble chips can be thrown on with a small fire shovel. This should be done, not facing the wall, but standing alongside, and with a back-hand sweep to get an even distribution of the material.

The surface of the wall should be such that a good key is obtained for the rendering. This can be obtained by raking out the joints and pitting the wall to give the mortar the necessary key. Alternatively, a light steel mesh can be plugged to the wall at the joints and given two or three coats of cement-mortar and finished off with rough cast tinted to the desired colour.

In the case of damp walls the rendering should be done when the wall is as dry as possible.

Sliding on the Dampcourse. The nature of the repairs will depend on the amount of movement. If the movement is slight, say up to 1½ in., pointing will be all that is necessary as there will still be sufficient bearing area for the brickwork (Fig. 1). Where the movement is large, a new 4½-in. wall can be built off the old footings and tied to the existing wall and a new portion of d.p.c. added.

Roof Repairs. Temporary repairs to roofs consist of laying roofing felt across the rafters. Light battens are then placed parallel and immediately over the rafters and nailed to them. Permanent repairs should be completed as soon as possible. Where the building has been open to the weather or, in the case of fire, saturated with water, special pre-

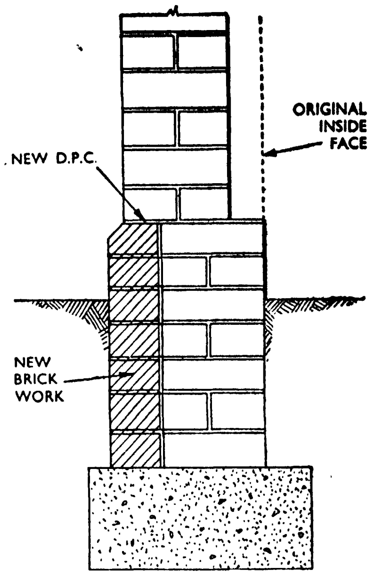


Fig. 1. Treatment of wall which has moved on the damp-proof course.
(Reproduced by permission of the Controller, H.M. Stationery Office.)

cautions should be taken. All air bricks should be examined and cleared from rubbish and other air bricks inserted if necessary. It is essential that a good through draught is constantly operating below the ground floor. All floor coverings should be removed together with any pugging between the ceiling joists. A few floor boards should be removed from the upper floors to allow free circulation of air.

Timbers should be examined for dry and wet rot, especially at their bearings and where the timbers are in contact with wet brickwork. All wet wallpaper should be immediately removed. A house dries out very slowly, and it is necessary to see that it is well ventilated. Advantage should be taken of suitable weather to keep the doors and windows open. It is

obviously quite useless to attempt interior repairs before the house is thoroughly dried out. Assuming that all the existing woodwork has been carefully examined and preservatives used where required, repairs to floors and skirtings should not present any difficulty. No woodwork should be painted until it has thoroughly dried out.

All timber that has been affected by dry rot must be burnt immediately on the site. Where dry rot has been found the remaining sound timber, and any new timber, should be treated with a suitable preservative.

Prevention of Rot

Bulletin No. 21 states that the ground-floor joists should be treated with a coal creosote or a similar tar-oil preservative; but for the treatment of skirting boards, panelling and joists on the first floor, creosote is unsuitable as the creosote is liable to bleed into the paint and plasterwork and cause staining. A solution of sodium fluoride, 6 oz. to the gallon, is advised. As this is colourless a little tracer colour should be used to show how far the solution has been applied. Two full coats of the solution should be given.

Where timber comes into contact with walls that are likely to remain damp and no other material can be substituted, the timber should be impregnated with preservative under pressure after it has been cut to size.

Fig. 2 shows an invaluable piece of equipment when carrying out roof repairs. It is an adjustable cripple and is used in the repair of ridge chimney stacks.

Façades. Bomb damage to façades that are capable of being repaired will need varying treatment according to the nature of the damage and the finished appearance that is desired. There will be the simple cases where the stones can be cut out and new ones inserted. The new stones must be exactly the same size as the old ones. Where the damage is extensive, it can be remedied by rendering in reconstructed stone.

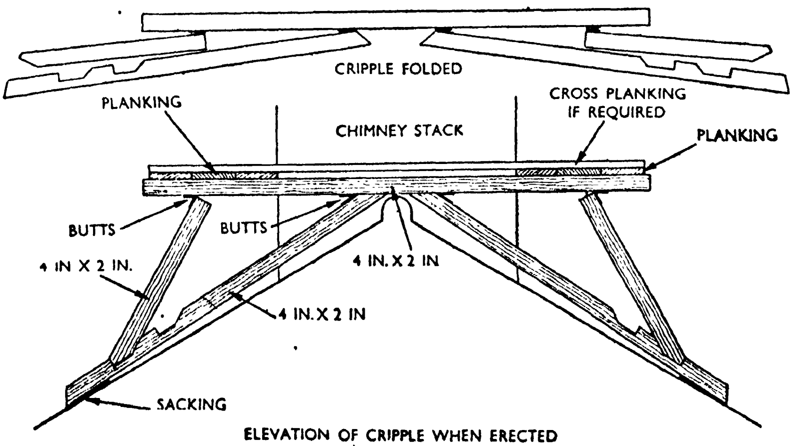


Fig. 2. Simple form of adjustable cripple which can be easily constructed on site. The cripple, which is shown in elevation, is employed in the repair of ridge chimney stacks. *(Reproduced by permission of the Controller, H.M. Stationery Office.)*

To do this the old work must be chipped to give a good key and the joints raked out to a depth of half an inch. All loose material must be removed and the work brushed down and hosed clean. The face should be well wetted before applying the first coat of rendering. This should be ½ in. thick in 1 : 4 cement and sharp sand, and should be well scored to receive the final coat. The final coat should consist of one part of cement to three parts of finely crushed stone. The crushed stone should be identical with the stone it has to match, and should be graded in a similar manner to the sand it is replacing. The first coat should be well wetted. The final coat, ⅜ in. thick, can then be applied and dressed off with a wood float. Excessive trowelling of the surface should be avoided.

Steel-framed Buildings

The steel-frame building has proved superior to any other form of construction in resisting aerial bombardment. In a steel-frame building that has received a direct hit the damage is limited. The limitation depends on the force of the explosion and the design of the steel frame, especially the connections and the bracing. If the building is well braced and its connections suitably designed, total destruction is rare and the effects of the bombing are localised. The damage will vary from a tangled mass of distorted steelwork to beams and stanchions that are buckled. However, in this type of construction repairs are not difficult.

Badly distorted steelwork should be cut by an oxy-acetylene flame into suitable lengths for handling and removed for scrap. Badly buckled beams and stanchions should be similarly dealt with, as they will not be worth the cost of removing for straightening. It is often possible to repair the steel frame by burning away the buckled portions and connecting the new parts by site welding. Damaged lattice steelwork especially lends itself to repairs by site welding. Repairs and replacements to steel-framed and reinforced-concrete buildings should be done under the supervision of a qualified structural engineer.

Girders and Roof Trusses

Damaged secondary members, such as internal bolted members of roof trusses, can be taken out and replaced after ensuring that the truss has been suitably shored to pick up the load. With riveted work, local strengthening by new members site welded will usually be found suitable.

The dismantling of main booms of large span girders and trusses which are badly damaged locally, and would necessitate the removal of a large area of flooring or roof framing, with consequent replacement, would be costly. To overcome this difficulty scaffolding should be erected to relieve the girder of its load locally, the damaged portion cut out with an acetylene flame, and a new section welded in position.

All connections should be examined. Where damaged cleats are riveted and the rivets partially sheared, it may be possible to make good the connection by site welding. With damaged bolted connections new cleats and bolts can be provided, unless the welder is already on the site, when it may

be advisable to make good the connections by site welding.

Damaged Filler Joist Floors. Of all types of concrete floors, the filler joist floor most readily lends itself to repairs. If only the infilling concrete is badly cracked it can be cut away. The surfaces at the joints of old and new concrete should be well hacked to provide key and brushed or hosed. A coating of cement-mortar, 1 : 1 about 1 in. thick, should be applied to the hacked surfaces before the new concrete is deposited. If any of the filler joists are badly distorted they can be removed, and new ones substituted.

Damaged Casings. Where the casings to the beams are damaged, the old concrete should be cut away, new binders inserted where required and the concrete made good.

Reinforced-concrete buildings have proved reasonably satisfactory against aerial bombardment. In the case of blast the reinforced-concrete building is superior to all other forms of construction. Reinforced panel walls are monolithic with the structure. There are no mortar joints and, therefore, there is no collapse of the walls, as in the case of the steel-frame building with panel walls of brickwork.

Reinforced-Concrete Beams

There may be cases where reinforced-concrete beams are not too badly damaged and are capable of being repaired. The beam should be carefully examined to see that the "bond" (that is, the adhesion between the steel and concrete) has not been destroyed. The beam should be relieved of its load by shoring the floor slab. Damaged concrete can then be hacked away from the rods, and buckled bars can be removed or cut away and new bars inserted. In the case of tension bars, sufficient bond length must be provided unless it is found possible to site weld the new rods. Damage to shear steel may be made good by the addition of stirrups.

Reinforced-Concrete Columns

The concrete usually spalls away from the steel and the rods buckle due to the effect of the load on the naked reinforcement. To repair such a column it must be relieved of its load, and the damaged concrete removed. The buckled steel rods should be cut out and new rods inserted. These should be given an adequate lap, or they may be site welded. Stirrups must be replaced and the column shuttered ready for pouring the new concrete. In many cases it will be more economical to replace the column entirely.

Joints between Beams and Columns. When a frame has had serious distortion due to the effects of partial collapse following an explosion, many of the joints will be strained. The extent of the damage will be revealed by the state of the cracks at the junctions of the beams and columns. Where the cracks are very pronounced, the damaged concrete should be cut away and any buckled reinforcement cut out and new bars and stirrups inserted. The concrete can then be made good as previously described. In other suspected cases a loading test should be imposed.

Reinforced - concrete floors which have cracked as the result of an explosion may be seriously affected. The extent and nature of

the cracks will vary, and permanent deflection may have taken place. If the cracks are pronounced and extensive, the slab should be renewed.

If the cracks are few and not pronounced, a loading test should be made. The procedure is as follows: A load equivalent to 50 per cent in excess of the designed load should be applied and a deflectometer reading to a $\frac{1}{1000}$ of an inch should be fixed beneath the slab. The load should be applied gradually and a reading taken at regular intervals. When the full load has been applied it should be left on for 24 hours and a reading taken on the deflectometer. The load should then be removed gradually and at regular intervals. When unloaded, another deflectometer reading should be taken. If this reading is exactly the same as the reading at the commencement of the test, and the maximum permissible deflection has not been exceeded, the slab can be regarded as satisfactory for its original use without further treatment.

Patent Floors

In such cases where the strength of a patent floor slab depends on a rib of reinforced concrete and the infilling is either a hollow block or is part of a self-supporting hollow unit, cracks in the ribs should be regarded with suspicion. Replacement of the damaged portion of the slab is the only safe procedure.

Foundations. Much of the destruction attributed to blast may have been caused by damage to the foundations. A heavy-calibre bomb which has penetrated a considerable distance into the ground causes more than the apparent disturbance shown by the crater. The explosion will loosen the soil over an extensive area and affect the surrounding foundations. As the damage to the foundations is not all obvious, it is liable to be overlooked. Therefore, a qualified expert should make his inspection before demolition or repair is commenced, otherwise the evidence upon which he could base his conclusions may be destroyed.

Damage to Drains

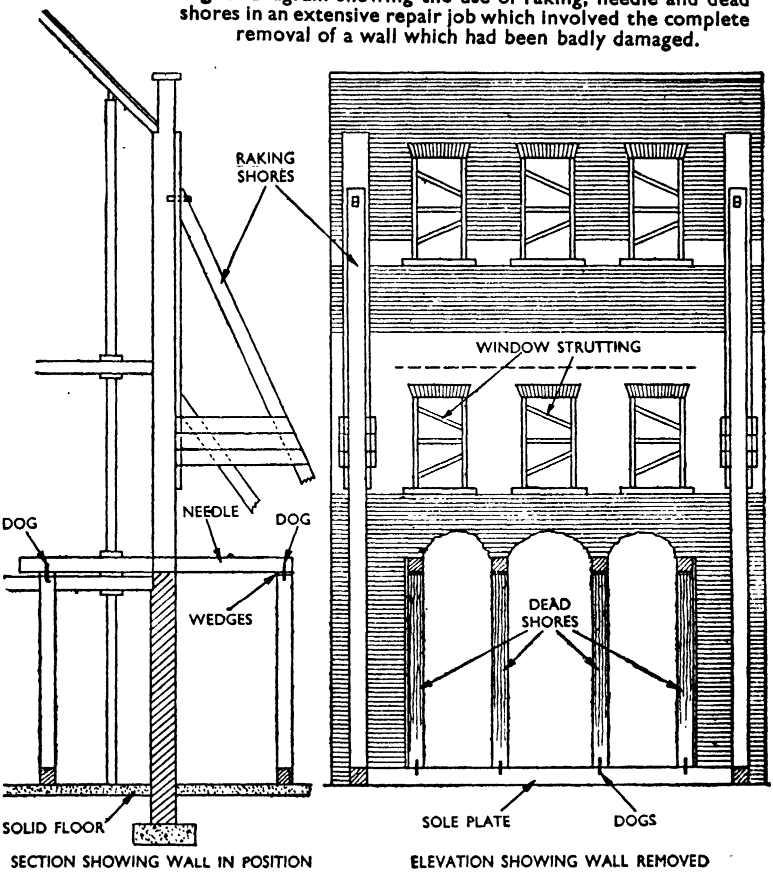
Bombs falling on or in the vicinity of buildings will damage pipes and drains. The interior damage will be apparent by the resulting streams of water, but the damage to the pipes below the ground will have to be located either by a smoke or water (head) test. There will be two cases: (1) the pipes between the inspection chamber and the building, and (2) the pipe from the inspection chamber to the interception pit.

The water test is carried out as follows:

In the first case the pipes in the inspection chamber can be sealed off, and the sinks and lavatories filled with water. These can be left for a few hours, and if there is no reduction in the head of water the drains between the building and inspection chamber are in order. In the second case the pipe in the interception pit can be sealed off. Having sealed all the pipes in the inspection chamber with the exception of the pipe to the interception pit, the inspection chamber can be filled with water. If, after a few hours, there is no reduction in the head of water, the drain is in order.

The smoke test is carried out by sealing one end of the pipe to be inspected and then inserting a

Fig. 3. Diagram showing the use of raking, needle and dead shores in an extensive repair job which involved the complete removal of a wall which had been badly damaged.



smoke cartridge in the other end, which is also sealed off. If no leakage of smoke can then be observed, the pipe is sound.

Shoring is the method of supporting, either by timber props or other material, the sides of a building, thus ensuring the stability of the whole structure.

There are three classes of shores used—namely, dead, raking, and flying shores (Fig. 3). Dead shores give support to the dead weight of a structure, and are applied vertically, usually in conjunction with needles. The needles are timber or steel beams inserted in the brickwork at about 6-ft. centres, and supported by the vertical posts. The vertical posts rest on a continuous sole piece, and are fastened to it by iron dogs. The needle is wedged up against the brickwork with oak folding wedges gently driven between the top of the post and the underside of the needle. The whole of the work is then secured with iron dogs.

The brickwork on which the

needle must bear must not be left jagged, but should be dressed and flushed with 1 to 3 cement mortar if required. This form of shoring is used where it is necessary to remove faulty brickwork below the needles. The shoring is placed there to take the whole of the load above. Before any needles are driven it is necessary and most important to strut the roof, floors and windows. Windows are openings in the structure and a point of weakness. These should be strutted between the reveals with two diagonals and a cross piece at the centre, say 4 by 2 in., and knocked in tight.

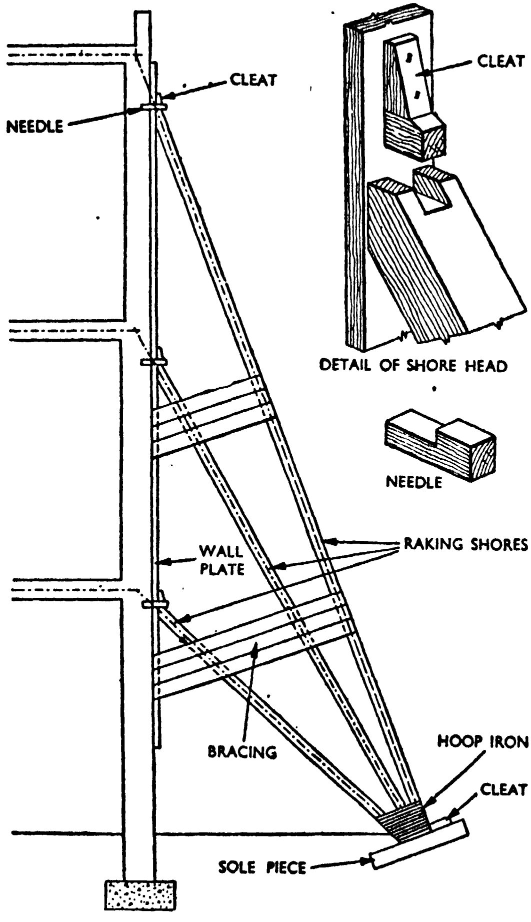


Fig. 4. Triangulated system of erecting raking shores. A simple system consists of two raking members and a wall plate which is spiked to the wall through the mortar joints. The shore head is recessed to take the head of the needle, thus preventing any possible side movement.

It is essential to see that the sole piece is resting on a solid bed. If not, it must be strutted up from below. If there is a series of dead shores they should be braced together with diagonal braces. If this is impossible on account of obstruction, knee bracing can be used. A timber cleat is usually placed at the head and foot of the knee-brace.

If the opening is extensive it may be necessary to use raking shores in conjunction with the dead shores, and if the opening extends almost the full width of the building the flank walls will need to be supported with raking shores. It must be emphasized that all wedging must be gently done to avoid vibration or the structure may be further damaged.

After all strutting and shoring is in position the faulty brickwork below the needles may be removed and if the foundations have been damaged they may be removed also. New foundations can then be put in and the brickwork built up to the existing work between the needles.

It is essential that at least seven days should elapse before any attempt is made to remove the shoring or the strutting, and this should be done gradually, first the strutting and then the shoring, to give the old work time to settle down on its new support.

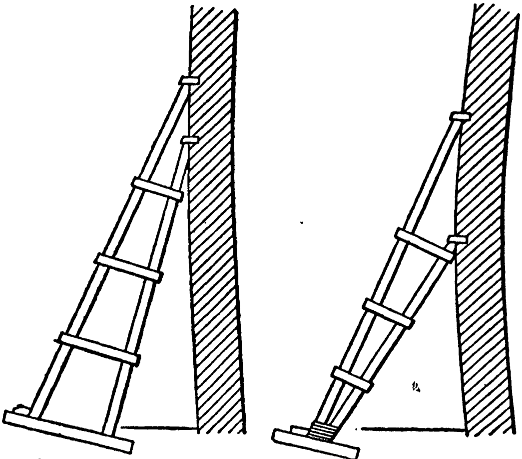


Fig. 5. Diagrams showing shores placed in correct position to accommodate two different types of wall bulge.

The foregoing method can also be used when large openings, such as new shop fronts, are required in sound existing structures. The strutting and shoring are carried out as above, and the work below removed. Piers are either left or new ones bonded into the existing work with a suitable foundation to take the load. Concrete or York stone padstones are bedded in cement on top of the piers to take the end of the bressummer. The bressummer is then threaded through the shores and placed on the battens, which are nailed to the shores about 2 ft. above the ground level. The bressummer is then jacked into position, being supported by temporary cross battens nailed across the shores to aid the erection. When the bressummer is finally in position the brickwork is built up to the existing work, and the same procedure as previously explained is adopted in removing the strutting and shoring.

Raking Shores. As the name implies, raking shores are inclined against the wall to be supported. The shore head rests against the wall and the foot upon a sole piece. The farther the foot is from the wall the greater is the capacity of the shore to resist the thrust. It is obvious that when the foot is brought close to the wall the shore is not being used effectively, as its capacity to resist the thrust is lessened.

As shown in Fig. 4, the shores are erected in a triangulated system. All the raking members are united at the base. A simple triangular system consists of two raking members and a vertical member known as the wall plate. The wall plate, usually 11 by 2 in. to 11 by 3-in. deal, is

spiked to the wall through the mortar joints. Its function is to spread the load from the shores on to the wall.

If the load from the shore head were localised, the shore head would probably push through the brickwork. The wall plate is recessed where required to allow the needles to pass through. The needles are usually 4 by 4-in. timber 12 in. long, cut one end to 4 by 3 in. to enter the wall, leaving a shoulder to butt against the wall plate. Above the needle is placed a shaped cleat nailed to the wall plate to give additional support. The shore head is recessed to take the head of the needle. This prevents any lateral movement. It is then secured by a wedge. The inclined shores are united at the base, and rest on a sole plate.

The sole plate is wider than the shore, and must be of such length that the safe pressure on the ground is not exceeded. The sole plate is inclined at an angle less than a right-angle to the outer shore so that it may be tightened. The foot of the outer shore is recessed to take a crowbar so that the whole system can be gently levered towards the building to pick up the load. A cleat is then nailed across the sole piece to prevent any slip. The shores are bound together at the base with hoop iron and dogged to the sole plate.

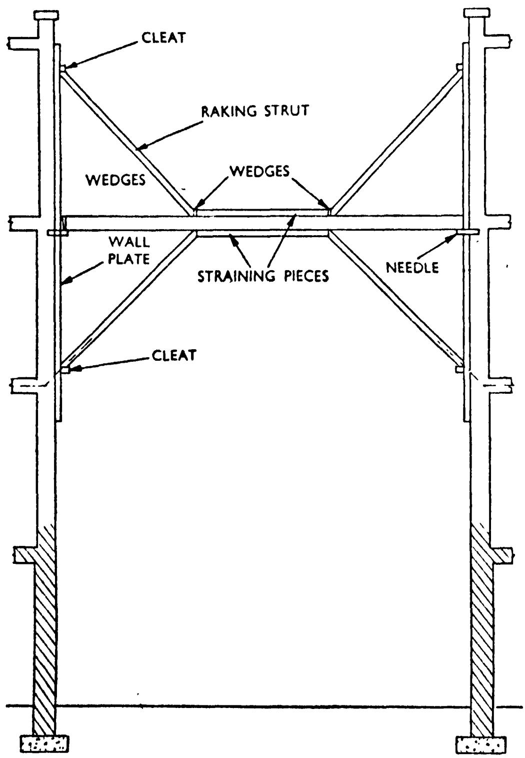


Fig. 6. Detail showing method of erecting flying shores.

The whole system is braced together with two or more 6 by 1-in. or 9 by 1-in. timbers at about 5-ft. centres, placed either side of the shores, and nailed to the shores, and the wall plate. These cross braces provide some resistance to buckling, and strengthen the whole system. In tall buildings the outermost shore is very long, and it may be difficult to obtain in one piece. It would also be inconvenient to handle. A rider shore is then used which stands on a piece of similar timber which rests on the back of the

second shore and on the sole piece. It is then tightened by folding wedges and secured by cross bracing nailed to the shores and the wall plate.

Correct Position of Shoring. It is important that the head of the shore is placed in the correct position. The centre-line of the shore should intersect the point where the needle meets the wall plate. If the shore is placed almost at the top of the wall it will be of very little assistance in resisting overturning. The intersection of the centre-lines of the floor and the shore should be on the centre-line of the wall. At the roof where the rafters are bearing on the wall plate the centre-line of the shore should pass through the centre-line of the wall plate.

Where bulges occur in the wall the position of the shore is dependent on whether the bulge is a sharp or uniform bend. A shore in the wrong place in a case of this sort would tend to aggravate the rupture (Fig. 5).

Spacing of Shores

Raking shores are usually spaced at 12 to 15-ft. centres and near the ends of the buildings. It must be remembered to shore "round the corner". If the front or back of the building is being shored, the flank walls will require to be shored near the end. Conversely, if the flank walls are being shored, the front or back walls will require shoring near the corners adjacent to the flank wall that is being shored.

Where a wall has been pushed out of the perpendicular and is in good condition—that is, no serious bulges or cracks are apparent and the foundations are sound—raking shores in conjunction with screw jacks can sometimes be used to push the wall back into the perpendicular. A job of this nature requires the services of a structural engineer, and should not be attempted without expert advice.

Flying Shores. Where buildings stand close together, such as in terraced property, it may happen that one of the buildings has been destroyed or has to be removed. The party walls may need to be supported, and the most convenient way to do this is by placing one or more horizontal struts between the walls (Fig. 6). Wall plates are spiked to the wall as previously described and needles are inserted through the wall plate into the wall to act as supports for the horizontal strut. This strut is then secured at one or both ends with folding wedges, gently driven to pick up the load. The flying shore is then braced with raking struts. These raking struts butt against stout straining pieces bolted to the main strut and at the other end they are secured by cleats, which are nailed to the wall plate. Folding wedges are then gently driven between the feet of the upper strut at the straining piece to tighten up the system.

The limit for this type of construction is usually about 30 ft. Scarfing or joining two lengths of the flying shore is very bad practice. Whole timbers must always be used.

Where the span is not more than 30 ft., flying shores are most suitable. They offer a direct resistance to the thrust, are economical and are out of the way of the building operations.

The underpinning of walls above the foundation level has previously been described together with dead shores. It is now neces-

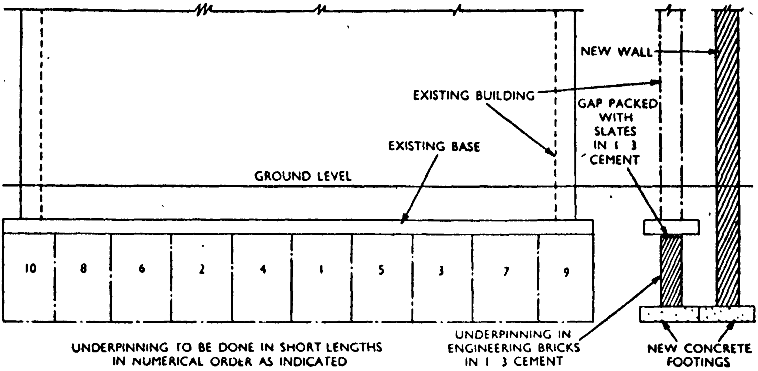


Fig. 7. Method of underpinning a wall in order to lower its foundations, and also, if required, to build a new wall alongside the old wall.

sary to consider the foundations in cases where (1) wider footings are required to take the increased loading on an existing structure; (2) where settlement is taking place and the foundations are suspected; and (3) where a new wall is built alongside another wall and the footings are taken down to a greater depth.

In cases 1 and 2 excavation is made for a length not exceeding 4 ft. and to a depth at least sufficient to allow the bricklayer to work his courses according to the width of the new underpinning, and to a bed capable of withstanding the load. Concrete footings of adequate width and depth to spread the load are then deposited. When these have firmly set, engineering bricks in 1 to 3 cement are laid to the underside of the old work. The gap left between the bottom of the old foundation and the top of the new brickwork should be packed tightly with slates laid in 1 to 3 cement (Fig. 7).

The first length should be commenced at the centre of the wall. When this has set, succeeding lengths can be built first left and then right of it; thus the operations are staggered. The last lengths to be put in are those at the corners.

In case 3 excavation is taken down to the level required and the concrete footings deposited capable of spreading the load from the old and new building so that the safe pressure on the ground is not exceeded. Brickwork in 1 to 3 cement of sufficient width to form the underpinning to the old and new walls is then built. The gap between the old and new work is packed with slate in 1 to 3 cement and the work completed in stages as previously described.

Settlement will occur in all buildings in varying degrees and if the settlement is uniform no serious effects will be experienced. Unequal settlement is very troublesome and precautions should be taken in design to prevent it. Bad design of the foundations is frequently the cause of the trouble. In such instances where one portion of the building is carried to a lower depth than the other, the footings should be stepped gradually up to the higher level.

CHAPTER 18

MATERIALS

CHOICE OF AGGREGATES. ASPHALT LAYING. USES OF ASBESTOS CEMENT. TYPES OF BRICKS. CONCRETE. CAST-IRON PIPES. JOINTLESS FLOORING. COMPOSITION OF PAINTS. PLASTICS. PLYWOODS. CLASSES OF PLASTER. ROOFING AND FLOORING MATERIALS. STAINLESS STEEL. NATURAL, ARTIFICIAL AND RECONSTRUCTED STONE. TIMBERS FOR EVERYDAY USE.

THE following is a list, alphabetically arranged, of building materials in common use for repair works to small properties.

Stress is laid on the *use* of materials rather than their composition, except where reactions on other materials or to climatic conditions merit special mention.

Aggregates. Usually the choice of aggregates is determined by the local supply available, but it is essential that those used should be resistant to change of composition or structure under all conditions. Natural hard stone, preferably granite, crushed to size, hard bricks of low porosity, broken to size, or natural flint or quartzite gravels are generally considered the best. Limestone, if used, must be carefully selected. For light-weight concrete, foamed slag or thoroughly burnt clinker is suitable.

Asbestos Cement. It may be said that this material has grown in popularity during recent years more than any other, and the variety of its uses seems to increase almost daily

Being a composition of asbestos fibres and Portland cement, asbestos cement products have the very obvious advantages of being highly resistant to climatic conditions, attack by vermin, rot, and most kinds of acid. The only disadvantages are a tendency to brittleness, and difficulty in decorating with oil-type paints, owing to the alkali content of the material. This latter can, however, be overcome by the use of suitable primers.

The following are some of the uses for which asbestos cement is supplied —

Corrugated Sheets. Made in lengths up to 10 ft. Suitable for fixing to wood or steel purlins. Ridge and hip pieces, eaves, filler pieces, apron and soaker flanges and barge boards can all be supplied in the same material.

This product is eminently suitable for covering garages, workshops, barns and outbuildings generally, and can be supplied in a small range of colours where so desired.

Flat Sheets. For internal linings to timber partitions and ceilings in place of the usual plaster or fibre boards, also for cover slips, soffit boarding and door panels.

Flat asbestos sheets are also available with decorated finishes to act as finished wall and ceiling surfaces; glazed finish,

for use in such places as bathrooms and kitchens; and grained finish, making a very suitable substitute for expensive wall panelling.

Miscellaneous. Bath panel risers, splashbacks, stove pipes, gas and electric fire surrounds (can be obtained in glazed finishes and for some products, decorated finishes), draining boards and shelving.

Pressure and Cable Pipes. For underground water, gas and electrical services.

Roof Trusses and Tubular Purlins. Not in common use for domestic work, being rather a new departure, but very useful for garages and outbuildings.

Roofing Tiles. Natural shade or in colours. All accessories, such as ridge, hip and valley tiles, can be supplied to match.

Soil, Waste, Vent and R.W. Pipes and R.W. Gutters. Manufactured in sizes similar to stock-pattern cast-iron fittings; bends, elbows and branches also being available. Fixing clips and brackets must, of course, still be metal.

Asbestos Wood. Available in flat sheets, and similar to asbestos cement, but having ingredients incorporated to overcome the disadvantage of asbestos cement in its reaction to great heats. Asbestos wood has very great fire-resisting qualities.

Asphalt. The principal uses of asphalt are the covering of flat roofs, waterproofing of walls and tanks below ground, and, to a lesser extent, as a flooring material. The type of asphalt which is used almost exclusively in all branches of normal building work is commonly known as mastic asphalt.

Mastic asphalt can be defined as a natural asphaltic rock, or certain other aggregates, mixed with a percentage of bitumen; but as this material is available in a satisfactory natural state in certain parts of Switzerland, France and Trinidad, it is a wise policy to use supplies from these sources.

Asphalt laying is done by hand after the material has been heated to a fluid state on the site of the works. It is recommended that when laid on concrete a stout building-paper underlay should be used, or a felt underlay when laid on boarding, to allow for slight movements in the sub-structure without cracking the asphalt covering.

Asphalt used as a flooring material is often coloured by the addition of suitable pigments during manufacture or processing but, up to the present, colouring is a costly process.

Bricks. Although bricks may be of clay, sand-lime, concrete or breeze base, it is proposed only to deal here with the most popular, namely, the clay-base bricks, as sand-lime and concrete bricks represent only a small proportion of the total bricks manufactured. Unless, therefore, local conditions are favourable there is no reason to diverge from the more common type. Breeze bricks are, of course, non-constructional, being used principally for joinery fixings.

Bricks, by reason of their use, can be broadly divided into four classes: (1) commons, (2) facing bricks, (3) engineering bricks and (4) miscellaneous.

Commons. the term "common" covers pressed, wire cuts, yellow or London stocks and certain hand-made bricks,

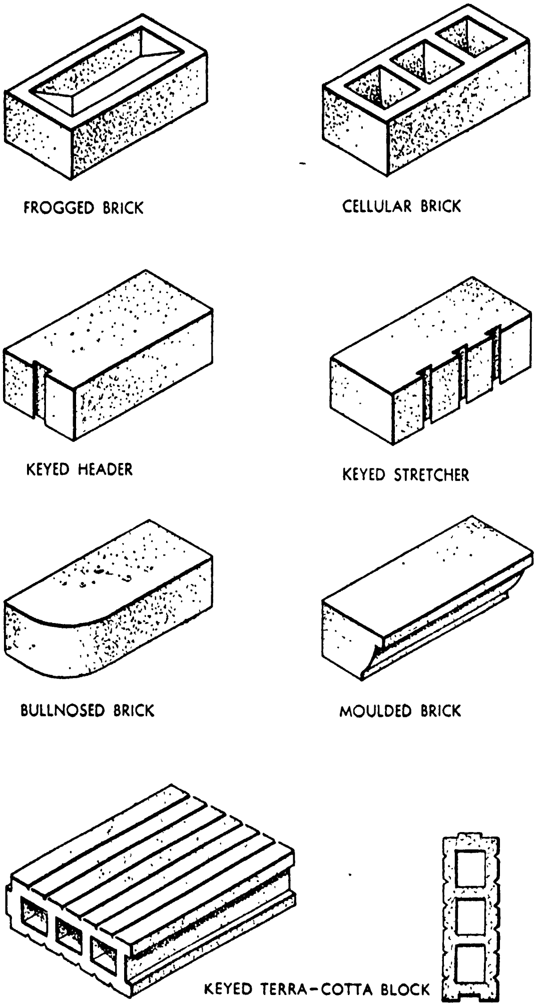


Fig. 1. General selection of bricks in everyday use.

generally used in all unexposed positions except where heavy loading must be considered.

The most widely used common bricks are flettons. They are semi-dry pressed bricks of regular shape and, most important, of low cost. These bricks are recommended for all work in the foregoing category where cost of transport *versus* local supply is not an issue. Where construction permits, cellular flettons can be used, having the added advantages of lightness and greater sound and heat insulation.

Engineering Bricks. Of extreme hardness, having a high crushing strength. For this reason they are used in positions where heavy loads must be provided for, such as in piers and foundation walls. Their very low porosity also makes them most useful in the building of walls next to earth, as in basements. Two or three courses of these bricks can be used to replace the normal slate or felt dampcourse commonly used in house building.

There are three well-known types of engineering bricks: the blue, red and brindle; the manufacture of the blue type is confined to Staffordshire and parts of Wales, while the reds and brindles are manufactured in many different localities. First qualities are pressed bricks, but a second-

quality wire-cut blue brick can be obtained.

Owing to their hardness, it is almost impossible to cut some of these bricks, but "purpose made" bricks can be supplied to overcome the problem of angles and bullnoses.

Facings. For good-class work a hand-made (rough or smooth), sand-faced brick is best, although the cost is rather high. Obtainable in multi-colours, reds, greys, these bricks give a pleasing, subdued tone never equalled by machine-made bricks, although the same range of colours is marketed. Whereever it is found possible, therefore, hand-made bricks should be used.

Gaults. White pressed bricks peculiar to South-East England, are also suitable for facings, but the colour limits their demand for this type of work. They are, however, useful as a cheaper substitute for white glazed bricks for use in areas and similar positions.

Miscellaneous. Rubbers are bricks which are burnt short of fusion and hence are not crystallized in the lump. It is possible, therefore, to rub them down to required shapes.

Moulded bricks are bricks moulded in a large variety of shapes for use on decorative brickwork and squints, and should be used in preference to rubbers where their range allows.

Firebricks are for use in fireplaces and in other positions where they are constantly required to withstand very high temperatures. They are made from refractory clays which contain a high and low proportion of silica and alkali respectively.

The common brown-glazed brick is obtained by the application of salt during burning. Another method is dipping, which provides a glaze obtainable in various colours.

Stocks. These are clamp-burnt bricks, thorough burning being ensured by the incorporation of breeze with the clay. Although these bricks come within the range of "commons" their high cost prevents their frequent use, and they find favour more as a facing brick (principally in the London district, on account of their resistance to atmospheric influences) than for work in unexposed positions.

A selection of common bricks is shown in Fig. 1.

Cast-iron Pipes. Generally used for external soil and waste pipes and rain-water pipes and gutters. Pipe ears are supplied cast on and jointing is done with red lead.

They are also used for underground soil pipes and water mains, principally with spigot and socket type joints, and, where cost allows, are preferable to stoneware pipes for sewage disposal.

The recognised method of caulking is by means of yarn and lead. For protection against corrosion these pipes may be obtained covered with a bituminous coating.

Cement. Composed of a mixture of chalk limestone and clayey material principally obtained from alluvial mud beds, burnt and then finely ground; the name Portland has become a household word in the building industry, largely on account of its unvarying quality. This cement, apart from the grade supplied for normal

work, is, by varying or adding to the composition, available in a number of differing grades for various classes of work, including waterproofing, rapid hardening, white and quick setting.

Coloured cements are available in a ready-mixed condition, or pigments can be supplied for mixing with Portland cement on the site. The former method, being a machine process, is considered safer, but when mixed on the site not more than 10 per cent of the weight of cement should be taken up by the pigment and very careful and thorough mixing is necessary if the best result is to be achieved.

One other type of cement which should be considered where rapid hardening is of importance is aluminous cement. A mixture of limestone and bauxite, it attains full strength in much less time than even the fastest of Portland cements.

Concrete. A composition of cement, sand, aggregates and water, mixed in proportions to suit the class of work for which it is intended. The principal use of this in relation to repair and small building work is for foundations, site concrete, pavings and lintels. The variety of mixes which can be used is very wide indeed, but as a general and reliable guide the following information may prove very useful:

For unreinforced concrete in mass such as to foundations a mixture of 1 : 3 : 6—that is, one part cement, three parts sand and six parts aggregate—is usually strong enough, the maximum aggregate size being 2 in.

For concrete used in rafts, such as concrete over sites and pavings, a mixture of 1 : 2½ : 5 is most common, the maximum aggregate size being ¾ in.; for reinforced work a suitable mix is 1 : 2 : 4.

For small areas of concrete flooring and flat roofs the use of precast slabs is generally more convenient than casting *in situ.* These usually have light reinforcement incorporated and are laid flat to bear on intermediate beams with grouted joints. Falls for water dispersal to roofs can be provided by a screeding of light-weight concrete having a pumice or foam slag aggregate.

Concrete Partition Blocks. These are available both solid and hollow, the composition for either being a light-weight concrete with, generally, a foamed slag or pumice aggregate. They are supplied grooved and keyed for bonds as required and made in various sizes to suit brick coursing up to 2 by 1 ft., the thicknesses usually being 2 in., 2½ in., 3 in. and 4 in.

Copper. A material which can be used for roofing, in the form of tiles, shingles or sheets, and ideal for dampcourses, but its high cost restricts its use.

Copper, for hot- and cold-water service piping, cylinders and tanks, has grown, and is still growing in popularity, primarily because of its anti-corrosion qualities, and the fact that very small-bore pipes are permissible in this metal making for neatness, and easy jointing and fixing.

Where, as is often the case, copper piping is connected to galvanized iron cylinders it is advisable to use brass couplings and washers.

Corrugated Steel Sheets. Mild

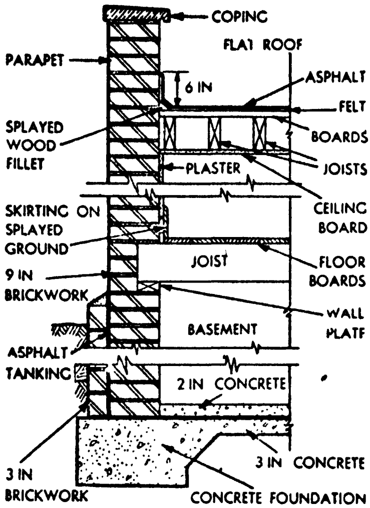


Fig. 2. Asphalted finish to flat roof and tanking of basement without areas, showing continuity of floor and wall dampcourses on concrete foundation.

steel sheets usually coated on both sides with zinc galvanizing, principally used for roofing, and sometimes for vertical work, on out-buildings. They also prove useful as shuttering to concrete.

Fixing is by means of washered hook bolts or drive screws.

Creosote. A very cheap and effective wood preservative distilled from coal-tar, but only suitable for hidden or exterior work. This material is particularly useful for the treatment of covered timbers such as fencing and gate-posts. The natural colour of creosote varies from black to brown according to the source of supply.

Distempers are merely whiting mixed, for ordinary purposes, with hot size. Tinting, if required, is arranged for by the incorporation of suitable colouring pigments during mixing. These are principally used as a finish to plastered ceilings, and, where tinted, are sometimes referred to as "colour washes".

For walls, washable distempers, also known as oil-bound water paints, are preferable. Comprising pigment, oils and stainers they are available in paste or powder form, covering a very wide range of colours and shades, and having the advantage of being very much cheaper than oil paints. They can also be lightly sponged down when dirty thus saving the high maintenance costs of ordinary colour washes.

Earthenware. Still largely used in the manufacture of sanitary fittings, particularly W.C. pedestals, and available in cane, buff, white or coloured glazed finishes, but superseded to a great extent, by fireclay in modern fittings.

Felt and its Uses

The principal uses for felt are: (1) Roofing (generally temporary structures); (2) insulation; (3) dampcourses and water-proofing.

For roofing, a variety of both bituminous and tar felts are marketed, the principal types being: (*a*) Unsurfaced impregnated bituminous felts used for underlayers on multi-layer felted, pitched or flat roofs; (*b*) sanded bituminous felts used where single-layer work is sufficient, or as the covering layer to multi-layer felted roofs; (*c*) slate, or mineral, surfaced bituminous felts used in place of (*b*); (*d*) self-finished bituminous felts, having, as the name implies, a smooth finish, used for single-layer work, all layers of multi-layer work, or in conjunction with impregnated felts as the covering layer on multi-layer work.

For (*a*) and (*b*) tar impregnated felts are also available, having an

identical base to the bituminous felts, but being impregnated with fluxed coal-tar pitch. Referred to generally as "tar felts" these are cheaper than the bituminous types but are not considered so durable.

For insulation under slates, tiles and asphalt, an open-textured flax or hemp felt, often referred to as sarking, is mostly used, the base being impregnated with fluxed coal-tar pitch, or in the case of "inodorous" felts, with wood tars. Where felt is used as insulation under slates on unboarded roofs it is preferable to use a reinforced bituminous felt to avoid sagging.

For dampcourses the recommended felt is a hessian base lead-core bituminous felt. For a material so important as a dampcourse small savings are not generally worth while considering, but ordinary reinforced bituminous felts can be, and quite frequently are, used for this purpose.

Fibre Boards

There are two classes of fibre boards, hard and soft. Both are composed of wood or vegetable fibres, the hardboards being compressed at high pressure to a smooth-faced finish, and both make excellent linings for walls and ceilings to receive direct decorations. They can also be used to replace plywood for panel filling in internal positions where cost is a consideration, and, being fibreised, this material is subject to very little movement. Fibre boards are supplied under a number of proprietary names, the common thicknesses ranging between ⅛ in. and ½ in.

Fireclay. Most modern sanitary fittings such as lavatory basins, sinks, bidets and urinals are composed of porcelain-enamelled fireclay, this material having superseded earthenware to a large extent on account of greater strength and other factors. All types of fittings are available in a wide range of colours.

Floor Tiles

For an inexpensive but durable floor finish to concrete pavings few materials can equal quarry tiles. Made from Staffordshire clay, these tiles are available in a small range of colours and are practically impervious, and when polished give a pleasing, warm appearance. Sizes vary considerably, the most common being 9 by 9 in. and 12 by 12 in. and the thickness usually between 1 and 1½ in.

A more expensive form of the above is the pressed clay paving tile. These tiles are usually of less thickness, smaller in size and have a very smooth surface, but although supplied in a much wider range of colours than ordinary quarries they are inclined to look "cold" when laid in large areas.

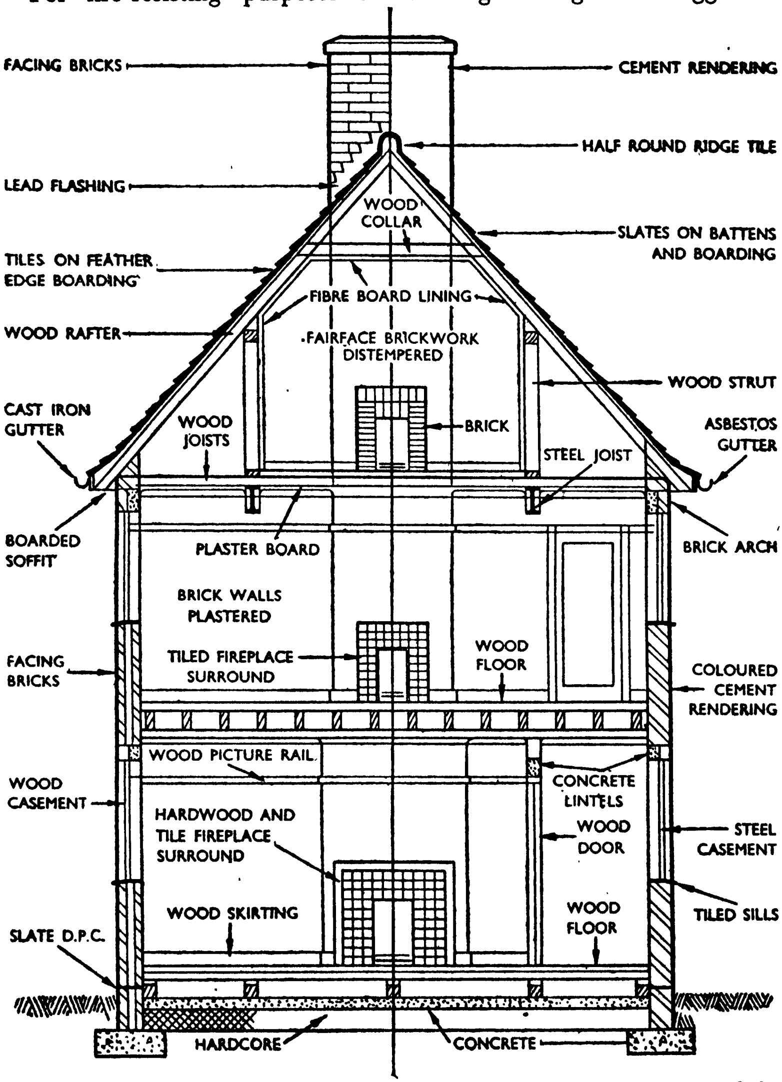
Glass. For glazing on domestic works flat-drawn sheet glass is generally used, the most common weight being 21 oz., although the weight is dependent on pane sizes and a range of between 15 oz. and 32 oz. is available. There are several grades of this type of glass, but O.Q. (ordinary quality) for best work and O.Q.R. (ordinary quality rejects) for garden frames and similiar unimportant positions, are suitable for everyday use.

Rolled glass is used for positions where obscurity is required and is obtainable in many different finishes to suit individual requirements.

Coloured opaque glass is becoming increasingly well known as a method of decoration. It is

supplied in a fairly wide range of colours, and is a very pleasing material for the lining of bathroom walls, shelving, splashbacks and table tops.

For fire-resisting purposes a wired glass is generally used, the best-known type being "Georgian wired", an obscured glass with square wire mesh incorporated. As an alternative to this, armoured or toughened glass is suggested



Sectional diagram of a house, drawn in two half-sections, showing some of the positions in which the materials described in this chapter are very frequently used.

for positions where appearance is important.

Glazed Tiles. Used for tiling walls of bathrooms, W.C.'s, kitchens and for hearths and cheeks of mantelpieces; these have a glazed finish on a clay backing and are available in a wide range of colours and several different facings.

Bull-nosed tiles, angle beads and coves are obtainable to provide a finish on edges, etc.

Normally tiles are set on a backing of cement and sand and are keyed for this purpose.

Glues. Joiners' glues are supplied as solids, liquids, jellies and powders. The first three are preparations from skins or bones, the fourth being casein or a resin glue. For general purposes the solid glue is considered most satisfactory, but casein or resin glue is very useful where damp conditions prevail.

Granolithic

A composition of cement and granite chippings, granolithic is used as ordinary surfacing for concrete pavings and thresholds. Aggregate should be maximum ¼ in. and free from dust, with a percentage of coarse grit or thoroughly washed sharp sand included, and is generally mixed in the proportion of 1 cement to 3 of chippings. Where possible, laying should be carried out before the base concrete has set so that the surfacing becomes integral with the base, but where laid on existing pavings it is essential to provide a good key, and advisable to keep to a minimum thickness of 1¼ in. If required to be non-slip, carborundum grit is incorporated at the minimum rate of 2 lb. per square yard.

Hair is added to the coarse stuff in plastering over laths to improve the key, prevent droppings and facilitate application. The hair should be ox, cow or goat, although certain vegetable fibres such as hemp are sometimes used as a substitute. They must be long and free from grease and dirt. The proportion used varies between 1 lb. of hair to 2 to 5 lb. of coarse stuff, the higher proportion being the better. But unless it is evenly distributed it is of little use, and it is far better to have less hair well spread than large quantities left in tufts.

Insulation Boards have a similar composition to fibre boards, but, being much less tightly compressed, have the great advantage of affording a high degree of thermal and sound insulation, and are particularly useful under roof coverings and for timber partitions.

Common thicknesses range between ½ in. and ¾ in. and, like fibre boards, are supplied under a variety of proprietary names.

Jointless Flooring. Used quite frequently as a floor finish to concrete pavings, these mostly comprise a magnesite base, sawdust, powdered cement or various other fillings and colouring pigments. The success of this type of flooring is more than usually dependent on first-class materials and workmanship, and where used, advantage should be taken of the great number of proprietary types offered by manufacturers of high repute. Low-priced varieties should, as a general rule, be avoided.

Lagging

Lagging has two main functions: (1) to prevent the freezing up of pipes and tanks in exposed positions such as roof spaces, and (2) to avoid loss of heat occasioned by

the large surface area of hot-water cylinders and tanks.

For wrapping pipes a hair felt is commonly used, secured with light copper wire. Cold-water tanks, where exposed, can be protected by casing and packing with slag wool or to a lesser extent by sawdust.

For the second function it is usual to render the hot-water cylinder or tank with a composition of magnesium and fibreised asbestos, applied in several coats and bound with small wire mesh or canvas.

Sheet Lead

Lead is principally used in sheet form for covering flat roofs, and for soakers, aprons and flashings. This material can be obtained either cast or milled, but for general building purposes milled sheets are most frequently used on account of cost and availability, although cast sheets are considered more durable. Lead sheets are supplied in various weights, but 4 lb. per foot is the most common, being suitable for small flats, soakers and flashings. Aprons, collars and large flats should, of course, be of heavier weights.

Lead pipes are used primarily for cold-water services, and have the advantage of flexibility. These should be of the weights and bores required by the various local authorities.

Soil, waste, ventilating pipes, cisterns and dampcourses are all available in this material, but high cost prohibits general use.

Metal Lathing. Expanded metal and perforated metal sheets are sometimes used in place of wood laths, being very convenient for other than straight work. These materials should be either galvanized or coated to avoid corrosion.

Mortar. The two types of mortar generally met with are (1) cement mortar and (2) lime mortar. As the names imply, the first is a composition of cement and sand, and the second of lime and sand, the cement generally used being Portland and the lime of a hydrated type. The common ratio of cement or lime to sand is 1 : 3, and in any case should not be stronger than 1 : 2 or weaker than 1 : 4.

Paints. As distempers, stains and varnishes have been dealt with, there are only oil paints and miscelleneous paints to consider.

The composition of practically all oil paints is a mixture of lead or zinc oxide pigments, drying oils, driers to control setting time, stainers for colouring, and thinners to obtain correct consistency.

Until recent years paints were supplied in paste form, and mixing was carried out by the painter, but today the practice of using "ready-mixed" paints has become generally accepted.

It is probable that the best oil paint for general use is a standard coloured white lead—that is, a paint having a base of genuine English white lead, mixed with linseed oil, coloured with natural stainers, only having barytes incorporated as a drying medium, and turpentine for thinning. This composition can be used internally and externally, and is known to have a very long life.

Paints for Inside Work

Zinc oxide pigmented paints are useful for internal work generally, and are frequently used as undercoats for enamelled work. They have the advantage of being

non-poisonous, and do not change colour as easily as white lead paints, but are prone to crack and blister if used externally.

Lithopone as a pigment is cheaper than the oxides, and can be used as an alternative to them for interior work, but, like zinc oxide, does not stand up to the weather in the same way as white lead.

The use of red lead as a pigment is, on account of its colour, generally restricted to priming coats for joinery and metal work, and has high protective qualities.

Eggshell and matt paints are obtained by an adjustment of the quantities of drying oil and turpentine to suit the required finish.

Enamels have pigments ground in highly refined linseed oil thinned down with gum resin varnish.

Flat paints are prepared by adding only a small amount of drying oil to the pigment and thinning down to the required consistency with turpentine.

Gloss paints should contain a high percentage of drying oil, and would thus require a smaller turpentine content to provide easy flowing.

Certain synthetic chemical paints are now available which are not covered by the foregoing and these must be used according to the manufacturers' instructions.

For painting on concrete, asbestos, cement and other surfaces where the use of oil paints is impracticable because of the alkaline nature of the material, a bituminous emulsion or bituminous paint is useful. The bituminous emulsion paint is used mainly on wall surfaces. Colours are available in a restricted range, but where used should be applied over a natural-base coat.

Silicate paints are valuable as low-priced waterproofers, and are unaffected by alkalis. Clear qualities can be supplied as base coats and colours for finishing coats.

Plasters can be broadly divided as follows to cover the classes of plasters generally used: (a) *Gypsum plasters*: retarded semihydrate and accelerated anhydrous; and (b) *Lime plasters*: quicklime and hydrated lime.

Gypsum Plasters

In modern practice the gypsum plasters are increasingly used, as they have the advantages of greater hardness and strength; they avoid the necessity of a change in type of plaster for angles; and they can be applied in one coat, if so desired, to certain backings such as plasterboard.

The backing for accelerated anhydrous plasters is usually cement and sand, while retarded semihydrate plasters are available in undercoat and setting coat grades. The setting coat in both cases is applied neat or very lightly sanded.

As gypsum plasters are supplied under a large variety of proprietary names, the maker's instructions in regard to application should always be carefully followed, and most particularly where applying skim setting coats on plasterboard linings.

Quicklime has the disadvantage of having to be run to "putty" at least four weeks before use, and, as this is unnecessary with hydrated lime, the latter is more frequently used.

Coarse stuff (*i.e.*, undercoats) used for lime plasters is generally

a 1 : 3 mix of lime and sand, although a stronger mix is sometimes necessary on lathed work. For the setting coat neat lime putty or lime putty mixed with small quantities of fine sand is used.

Plaster boards are composed of a layer of gypsum plaster reinforced either side with stout paper of a quality suitable for acting as a key, by penetration, for subsequent plaster coats; and are made to widths allowing for nailing to joists at all commonly used centres. As hardly any movement takes place in this material, the danger of cracks developing in the finishing material is small, but the precaution of scrimming the joints before applying plaster is advisable.

Plaster Wall Boards are similar to plasterboards, but the covering to the plaster core is carried out with a compressed, smooth-finished paper which enables them to be used as linings to walls and ceilings without the necessity of applying a plaster finish. Joints require filling and covering, and the material is then ready to receive direct decorations.

Plastics in Building

A study of plastics is certainly well worth while, as the possibilities of these in relation to the builder's work are almost limitless. At the present moment the chief function of plastics, as applied to the class of work dealt with in this chapter, is as an alternative to wood, and iron, electrical and ironmongery fittings and casings. There appears to be no reason to doubt that, in the near future, doors, fireplace surrounds, tiling, wall and ceiling linings, floor finishes and a host of other things made of plastics will be marketed, generally, however, in combination with wood, owing to the relatively high cost of plastics.

As a substitute for wood and metalwork, plastics have in the past been avoided by some builders on account of their supposed brittleness; but, except perhaps in the cheaper varieties, this is a fallacy, as fittings manufactured from plastics are of equal, and in many cases greater, strength than the materials they supersede.

The composition of plastics cannot easily be defined, but generally they are synthetic resins mixed with wood flour. Cotton, coal by-products, and milk are, among other things, used in the various manufacturing processes.

Plastics hold many advantages over most materials, among these being high resistance to climatic conditions and attack by vermin or rot; they form a permanent decoration, thus obviating maintenance costs; they are supplied in any colour or combination of colours and in any finish from flat to high polish; and they will saw and drill in the same way as wood and iron.

Plywood. Plywoods, useful for their strength to thickness ratio, are used for panels in, or coverings to, doors, cupboards, spandrel framing and balustrading, and can be obtained in thicknesses ranging from $\frac{1}{8}$ in. to $\frac{1}{2}$ in. comprising anything between three and seven plies.

The great advantage of plywood is that it can be faced either on one or both sides with veneers of the more expensive woods such as oak, mahogany and silver walnut, thus bringing the beauty of these woods within the reach of small property-owners. Panelling in this material, if properly carried out, can be indistinguishable from

genuine solid construction. For great durability metal-faced plywoods are also available, and resin-bonded plywood can be obtained for use in external positions.

Putty, for securing glazing, is generally known as linseed oil putty or gold size putty, the first being used for glazing to wood and the second for glazing to metal.

Both types are a composition of finely powdered whiting and linseed oil, but a percentage of gold size is added to the latter type.

Roofing Tiles

By far the most popular of roofing materials, tiles fall into two classes: (1) clay tiles, hand or machine made; and (2) concrete tiles. These are available in various shapes, such as plain, plain cambered, interlocking and pan, the latter also being obtainable with glazed finishes if required.

The manufacturing process and the colour range are very similar to those for bricks, and, like bricks, there is nothing to equal a hand-made sand-faced tile for the subdued, pleasing tones acquired by weathering. Cost often determines the use of machine-made clay or concrete tiles.

Cambered tiles are supplied with nibs to hang on battens and nail holes for fixing; but, except on very steeply pitched roofs, tiles are seldom nailed every course, and on flat pitches nailing may be carried out as low as one course in every eight.

Concrete interlocking tiles are an alternative to cambered tiles, and can be used in similiar positions.

Pantiles, which are also available in a fairly wide range of coloured glazed finishes, do not give protection against weather to the same extent as other tiles, and are used preferably on boarded and felted roofs only. Also, being heavier than other tiles, the necessity of increasing the size of roof timbers arises, and the combination of factors somewhat restricts their use except, of course, on the much more expensive classes of work.

Rubber Flooring has become very popular for the covering of floors in bathrooms, kitchens and similar positions. It is easily kept clean; has the advantage over linoleum of being unaffected by standing water; does not cause tiredness in the way common to tiled floors; and gives permanent decoration. Obtainable as solid rubber or rubber on a backing of another material, it can be supplied in sheet or tile form, and is normally stuck down to the sub-floor with a rubberized cement mastic.

Sand. The principal uses of sand are, of course, for concrete, renderings and plaster work, and should, wherever possible, be from river, or pit. If neither of these is available crushed stone can be used as an alternative, but careful selection is necessary. Sea sand should only be used if carefully processed to remove the salts, and this is usually costly if correctly carried out.

Slates

Slates are used extensively for roofing and to a lesser degree for dampcourses, cisterns and shelving. They are quarried from natural rock beds in Wales, the Lake District, Cornwall and Scotland. It is generally considered that slates from North Wales are the best, but choice of the source of supply is dependent upon the proposed use, as the range of

colours, thicknesses and durability are determined by the bed from which the slate is quarried.

Stainless Steel. The usual process of rendering steel stainless is to incorporate a percentage of chromium and perhaps certain other alloys. In domestic building work stainless steel is useful for flush pipes, sinks and drainers and for decorative metalwork.

Stains are supplied in water, oil and spirit qualities, the latter two being the more durable. They are available in a wide range of colours, and form a pleasing and cheap finish for internal joinery. Oil stains are most frequently used, but water stains are satisfactory if a coat of varnish is applied.

Types of Stone

Natural stone is not a very common building material as far as domestic work is concerned, but is sometimes used where local quarries make this advantageous. Of all stones, granite is considered best from the point of view of durability; but limestones and sandstones, being softer and therefore easier to work, have advantages for decorative stonework. Generally, however, the decision to use, as well as the type of, stone is dependent on supplies available from nearby sources.

Buildings can either be erected with stone blocks or stone faced on a brick or similar backing in thin slabs.

Reconstructed stone, that is, precast concrete blocks or slabs faced with a mixture of crushed natural stone and cement, is used very extensively now in place of natural stone, as it has the following advantages over its naturally produced counterpart: (1) Flaws and other defects sometimes found in natural stones do not occur in reconstructed stone, the stone facing being integral with the concrete backing; (2) for carving and decorative effects reconstructed stone is treated in the same way as natural stone, but simple patterns can be arranged for in casting; (3) reinforcement can be introduced where required to act as a beam or lintel and take heavy loadings; (4) generally, reconstructed stone is of lower cost than natural stone, is not bound to a restricted range of sizes, and is thus more easily handled, though often it does not weather so satisfactorily.

Artificial stone is also being used now as a building material instead of natural stone, and is, as the name implies, a composition of sands and cements, mixed to produce a concrete with the superficial appearance of stone. Of course, the effect produced does not equal natural or reconstructed stones, but this is offset by the low cost. Naturally, it can be treated in the same way as concrete for precasting moulds and panels.

Other Uses of Stone

Both reconstructed and artificial stones are used primarily in the form of ashlarings and linings on a backing of brickwork.

Apart from the building or facing of walls, stone has many other uses, a few of which are enumerated below:

Balustrades.	Quoins.
Copings.	Stairs.
Door surrounds.	String Courses
Parapets.	Thresholds.
Pavings.	Window sills.
Plinths.	

Terra-cotta. Produced from clay, this material is only used to any

extent in domestic work in the form of hollow partition blocks. These blocks have the advantage over breeze blocks of greater thermal and sound insulation. Made in sizes to allow for block-bonding to brickwork, they can be supplied either self-faced or keyed to take rendering coats. Other uses are for chimney-pots and land drains.

Timber

The range of timbers in every-day use includes the following:

HARDWOODS: *Iroko*. An African wood similar to teak, and generally used where the qualities of teak are required without entailing the very high cost. Oil or polish as for teak.

Mahogany. A very fine but also very expensive wood, principally used internally for high-class panellings, mouldings, cabinet work and veneers. Polishing only is required.

Oak. English oak is perhaps the best known of all hardwoods, being used on even low-priced work for window sills, door thresholds and handrails, and on better-class work for flooring, stairs, doors and, where the style permits, for casements, wall panelling, mouldings, half-timbering and exposed roof trusses. When quarter sawn this wood shows really excellent figuring. Needless to say, finishings are unnecessary, and polishing or fuming for internal work and oil dressing for external work are adopted.

Austrian oak, being less costly, frequently takes the place of English oak and has the advantage of being less subject to movement, but is not considered to be so finely figured. Surface dressings should be as for English oak.

Teak. A much harder wood than oak, used in domestic work for draining-boards, table and dresser tops, and fire-resisting construction. Where price allows, this is an excellent wood for all positions where really hard-wearing qualities are required. Dress with oil or wax polish.

SOFTWOODS: *Douglas fir* (or *British Columbian Pine*) has strength and durability, but is rather coarse grained. Its uses are similiar to pitch pine, and the same difficulties in finishings are encountered.

Pitch pine is a border-line case between softwood and hardwood, although generally recognised as a softwood, and is used where greater strength is required than deals can offer. It is particularly suitable for floorboards, stairs and other positions where heavy wear is experienced. Finishings must be carefully selected as this is a coarse-grained wood which is inclined to show through.

Red and Yellow Deals

Of North European origin, red and yellow deals are the primary "common purpose" woods, used more frequently than any others for general carcassing work, floor- and roof-boardings and joinery such as doors, frames, casements and staircases. Red deals should be used in preference to yellows for exterior work, as these have a higher resin content. Finishes to joinery work can be applied without difficulty.

Spruce. The principal source

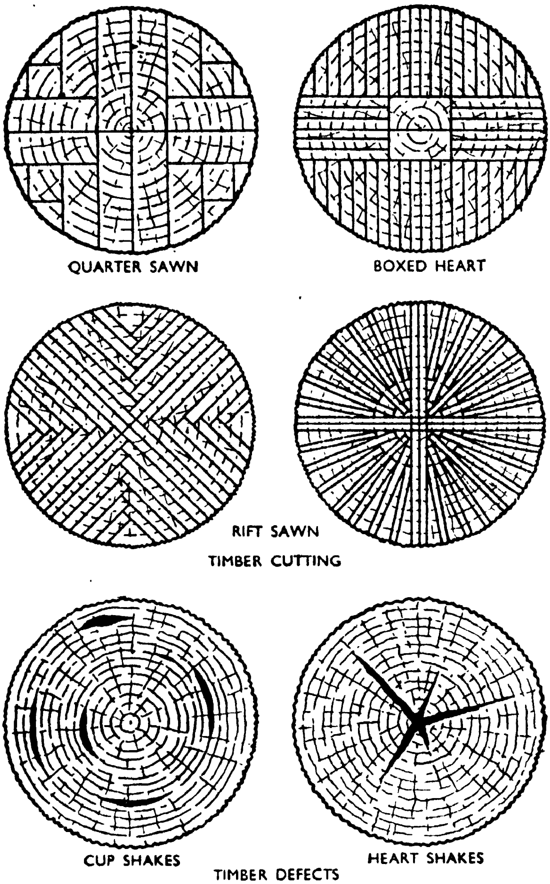


Fig. 3. (*Top section*) Various methods of sawing timber. (*Bottom*) The two most common defects found in timber.

of supply at present is Canada, and its uses are similar to deals, although it is perhaps not quite so durable, and should for this reason be restricted to interior works. As in the case of deals, finishing to joinery work does not give rise to any undue difficulty.

Western hemlock is also a Canadian wood, and is exceedingly useful for better-class joinery work where a higher grade wood combined with the ability to take any kind of finish is required.

Varnishes. Providing a hard, glossy and durable finish over flat oil paints and stains, varnishes comprise a mixture of hard resins with drying oils. Driers and thinners are used as for paints. Used externally, this material should be allowed to dry very slowly by using a high percentage of oil, but for internal work and flattings (undercoats) the oil content can be reduced if necessary in order to accelerate drying.

Wrought Iron

Used very frequently for water and heating service piping, wrought iron has great strength, but at the same time it is soft and can quite easily be bent cold. Decorative ironwork such as gates and balustrades are generally carried out in this material, as it can be far more delicately worked than is possible with cast iron.

Zinc. Generally used as a cheap substitute for asphalt or lead in covering flat roofs, and for valley gutters, flashings and aprons. If properly laid, this material is quite satisfactory in work where a very long life is not of first importance.

CHAPTER 19

BUILDING LAWS

DEFINITION OF REPAIRS. MODEL BY-LAWS. COMPLICATIONS OF BUILDING LAWS AND BY-LAWS. NATURE AND PURPOSE OF BY-LAWS. MODIFICATION AND WAIVER. CONTACTING THE LOCAL AUTHORITY. SPECIAL LOCAL LAWS. RIGHTS OF ADJOINING OWNER. BUILDER AND EMPLOYER.

ANYONE engaged in building repairs will soon discover that his work comes within the control of a number of Acts, by-laws, regulations and, in some circumstances, special Ministerial rules and orders, all of which may conveniently be generalized under the term "Building-Laws". The earlier this discovery is made, the better, as an advance knowledge of legal requirements may save the builder considerable trouble and expense after the work has been done.

Definition of Repairs

It must not be inferred, however, that repairs are the special target of the building-laws. On the contrary, much of the work coming within the scope of the term "repairs" may proceed without any restriction whatever. The only necessity for the observation of legal requirements arises from the fact that much of the work customarily designated "building repairs" comprises operations outside the more restricted legal acceptation of the expression. The building-laws regard repairs as nothing more than the making good of the fabric necessitated by wear and tear, age and weather, or other natural or accidental causes. The term is taken to imply the retention of that which is repaired; while the removal and replacement of any part of the structure is regarded as new work.

It is not to be concluded, however, that in practice the introduction of new materials is entirely prohibited in repair work, or that such operations are limited to painting and paperhanging. The head of a chimney-stack might receive a new creasing and be recoped and flaunched, without any question of the building-laws being involved; yet it has been held that to demolish the stack and rebuild it, is a work of reconstruction and therefore subject to a number of requirements relative to the size of the flue, the thickness and nature of the surrounding material and to its height. Even without demolition, an increase or reduction in height might be regarded as an *alteration*, and therefore subject to control.

Extensions

Again, the making good to a leaky roof by the insertion of a new slate—or several new slates—might pass without official notice, provided the process were not amplified to the extent of a "reconstruction". But supposing a side-passage existed between the building and the boundary-wall, and the builder roofed over the intervening space merely to pro-

tect the side-door, this would constitute an extension and he would be called upon to observe not only such laws as relate to roof construction, but all those relating to the effect of his work on the building as a whole. For instance, the new enclosure might result in rendering ineffective the ventilation or lighting required by the building-laws in the adjacent part of the house.

The Dividing Line

To the builder whose signboard bears the legend "Building Repairs", the question that will naturally present itself will be: "Where is the line to be drawn between repairs on the one hand, and on the other, alterations, additions and reconstructions?"

Were it possible to formulate a simple definition applicable to all the various operations comprised in works to existing buildings, it would probably have been included long ago in the building-laws. As it is, every case must be judged on its merits, bearing in mind that the underlying principle of the differentiation is to ensure due supervision and control of all works to existing buildings where the works are of such a nature that the manner of their execution *could* have the effect of bringing an existing building out of compliance with the building-laws. When in doubt, the builder would be well advised to consult the responsible authority, and if it be agreed that the work is in fact in the nature of repairs, he may feel safe in proceeding without further anxiety.

Even in the case of a building which is not in compliance with the building-laws—as for instance where the building was erected prior to the making of a certain law with which it does not now comply—unless such a building is in a condition that can be regarded as dangerous, the controlling authority cannot make the execution of necessary repairs a pretext for requiring an old building to be brought into conformity with laws made subsequent to its erection. This is a generally accepted principle, the reason for which is obvious; for, were it otherwise, and by-laws were made to be retrospective, the result of every revision of a set of by-laws would have the effect of requiring alterations to all the buildings of the locality affected by such by-laws.

Model By-laws

The Model By-laws of the Department of Health for Scotland sum up the situation in the following clause:—

"Except where otherwise specifically provided, these by-laws shall not apply to or in respect of any existing building, unless and until such building or any portion thereof is rebuilt or reconstructed or otherwise altered or added to after the time when these by-laws come into force; in which case the rebuilding, reconstruction, alteration or addition shall be carried out in conformity with the requirements of such of these by-laws as are reasonably applicable."

Apart from whether the nature or extent of the work amounts to an alteration or new construction, or even where there are no repairs at all and the physical conditions of the building remain unchanged, the requirements with which building-work must conform are bound to vary according to the nature of the building concerned.

For instance, some of the rules relating to strength and stability

might be more stringent in respect to a warehouse than to a dwelling-house, while, conversely, there might be demands in regard to the provisions for light and air to the domestic building which are unnecessary in the case of the warehouse. If, therefore, an existing structure built for human habitation is subsequently used as a warehouse, the whole question of conformity with building-laws must necessarily be reconsidered in the light of the change in the purpose for which the building is to be used, just as though the structure itself had been materially altered.

Extension of Powers

Section 62 of the Public Health Act, 1936, forms an apt synopsis of the foregoing principles relative to the applicability of building-laws to extensions and alterations (including that due to change of use), and also the exemption of buildings from laws made subsequent to their erection, where such buildings are still employed for their original purposes. While empowering local authorities to make by-laws for regulating specified matters in regard to new buildings, this Act proceeds to extend the powers, and consequently the application, of the by-laws to:—

"(*a*) structural alterations or extensions of buildings so far as affected by alterations or extensions;

"(*b*) buildings or parts of buildings in cases where any material change, within the meaning of this section, takes place in the purposes for which a building or, as the case may be, a part of a building is used, and so far as they relate to matters mentioned in this subsection may be made to apply to buildings erected before the date on which the by-laws came into force, but, save as aforesaid, shall not apply to buildings erected before that date."

Then follows a number of instances of circumstances constituting "a material change in the purpose for which a building, or part of a building, is used", concluding with the following comprehensive paragraph:—

"Where by-laws contain special provisions with respect to buildings used for any particular purpose, a building or a part of a building, being a building or part not previously used for that purpose, becomes so used."

Patchwork of Building Law

The system of legal control (if it can be termed a system) as applied to the business of building in its wide sense, is comprised in a branch of legal literature involving the operation of the various Building Acts and Public Health Acts, as well as the laws relating to housing; town-planning; sanitation; the rights of adjoining owners; rights of way; rights of light; and a host of other rights, including the ordinary legal rights appertaining to ownership and applicable to building or land.

The paths over this vast wilderness are rendered the more thorny by the fact that the various Acts of Parliament and the by-laws, rules and regulations made under their authority are of necessity amended from time to time. This would not matter so much if one were able, after such an amendment, to discard the old Act and find the whole duty of man in relation to building, by purchasing a copy of the Amendment Act.

But the process of amendment consists generally of the passing of an Act covering only the amendment, and repealing only those parts of the previous Act which would be inconsistent with such amendment, leaving much

of the matter in the previous Act still operative. Thus the enquirer, having purchased the latest Act, will find that he has not the whole story after all; and, when he has obtained the previous Act, will very possibly discover that this Act in turn is an amendment of a still earlier Act to which he must refer—and so on.

Fortunately for the builder whose operations are limited to repairs and such minor alterations and extensions as are usually included under that designation, his work will confine him within a relatively small plot in the wilderness of building-laws, and it will rarely, if ever, happen that he will be let and hindered by many of the legal obstacles and pitfalls which lie in the path of the general building contractor whose way lies over the whole field of building.

Nevertheless, it behoves the builder, however limited his sphere, to be on his guard against the possibilities of a breach of some law which, though not directly relevant to the actual work executed or the building concerned, may relate to some indirect infringement on the rights of adjoining owners or of the public.

Building By-laws

The majority of legal contacts, however, will be found to be those in relation to the local building by-laws rather than with legislation regulating things outside the boundaries of the building immediately concerned.

These by-laws are made by the Local Authority (subject to their approval by the Minister of Health in England and the Department of Health in Scotland) and naturally, like the Acts, they are revised from time to time to keep abreast of developments in building science and the advent of new materials and methods of construction; but with this advantage, that every new set of by-laws, as issued, is generally complete in itself and does not relate to previous laws as do the Acts of Parliament.

Local Differences

As might be expected in such a distribution of legal control, the by-laws of one Local Authority may differ from those of another in some particulars, though such differences are not so marked as might otherwise have been the case, owing to the fact that the responsible Minister or Department issues a complete set of "Model By-laws" (which are also revised from time to time) for the guidance of Local Authorities in their work of framing by-laws for the control of building in their areas. And since such by-laws are subject to the approval of the Minister or Department, it will readily be understood that, as a general rule, by-laws of the various Authorities have a strong family resemblance to the parental model, and consequently to each other.

Nevertheless, the general similarity between the various local by-laws with their minor differences is in itself a snare to the unwary. In the circumstances it may happen that whereas one Local Authority requires or permits a certain thing to be done, another Authority operating outside the boundary of the first—possibly just across the road—has legislated otherwise, and it is easy for the builder accustomed to working

in the one area inadvertently to transgress the by-laws of the other.

There is only one certain way of avoiding such a happening. Wherever it is proposed to carry out works (otherwise than such renovations as come within the restricted legal meaning of repairs) the person responsible should obtain from the appropriate Local Authority a copy of their building by-laws—*and study them carefully*. The importance of this cannot be over-emphasized.

Objects of By-laws

The local building by-laws are made by the Local Authorities by virtue of powers conferred by Acts of Parliament. In conferring these powers, the parent Acts generally indicate the purposes and nature of the by-laws contemplated, and in so far as the by-laws are such as to be within the limits thus set, they have all the force of the laws of the land in respect of the locality where such by-laws are applicable.

It is the function of the Local Authorities to administer the by-laws they have thus made. It will be appreciated that persons elected to carry out the multifarious duties of a Local Council are not necessarily versed in building matters, but that both in the making and the administration of building by-laws, they act under the guidance and advice of a staff having specialized knowledge and experience in such matters.

Generally, the by-laws are binding not only on the builder, but on the Local Authority inasmuch as the Authority cannot demand anything in excess of what is laid down therein unless, of course, empowered so to do by some Act or other authoritative legislation. The Model By-laws issued by the Department of Health for Scotland "for regulating building, etc. in Burghs" provide a warning of the possibility of there being other requirements outside the by-laws, by the inclusion in the by-laws themselves of the following:—

"Nothing in these by-laws shall be deemed to restrict any power competent to the Dean of Guild Court to require anything in connection with the erection or rebuilding, reconstruction, or other alteration of or the addition to, a building notwithstanding that the same is not required by these by-laws."

Nevertheless, in executing works of the nature herein contemplated, it will be found that in practice there are relatively few things entailing legal obligations with regard to actual building which are outside the scope of the building by-laws. Even where such outside requirements impinge on the work of a minor alteration or addition to a building, they will, in most cases, be under the jurisdiction of the Local Authority, and the builder's attention will probably be directed to them before he has proceeded so far as to be in the unfortunate position of having transgressed the law unwittingly.

Reasonable Safeguards

Although the observance of the local building by-laws does not constitute an infallible safeguard against all the legal dangers besetting the path of a builder, yet so long as his operations are confined to such works as are usually designated repairs, a knowledge of the by-laws will reduce his danger to a minimum.

In studying the building by-laws, one should have in view the underlying object of a by-law, in order to appreciate the spirit as

well as the word of the law. In the early days of the public control of buildings, this was an easy matter, as the purpose of building-law was generally restricted to the prevention of the spread of fire. The direction however of the course of revision has been, and is, towards extending the scope of control. This trend may be seen by glancing at past and present legislation.

The Public Health Act, 1875 (which conferred on Local Authorities powers to make building by-laws), specified their purposes to be "for securing stability and the prevention of fires, and for purposes of health," and also "to secure a free circulation of air" (which also might have been assumed to relate to health). In the Act of 1936, however, the specification of the purposes to be served was deliberately omitted, and it has been officially explained that "the omission of these restrictive words enables the scope of the by-laws to be enlarged".

Expansion of By-laws

While the Model By-laws of 1937 do not appear to have widened in their underlying purpose to any great extent, yet the omission has the effect of leaving the door open for other purposes to be served by future by-laws; and in view of the general changes and developments to be anticipated in our modes of life, the extension of the purposes behind our building-laws will probably be accelerated.

In what directions the expansions are likely to take place it is difficult to foretell. It is notable however that the Scottish Model By-laws have already exhibited an expansion beyond the limits of the old trinity of stability, fire and health. This development (which might be characterized as "habitability" or "convenience") includes such matters as baths and their fittings; scullery sinks, wash-tubs and wringer-boards; even stretchers and pulleys for convenience in drying clothes; hand-rails to staircases; artificial lighting; cooking facilities, and sound-insulation.

In many cases the principal purpose of a by-law is obvious. The requirements relative to foundations, for instance, must naturally suggest stability. But so do the rules regulating the thickness of walls; and yet a thoughtful perusal of some provision—say the extension of the party wall to the surface of the incombustible cover of a timber framed external wall—at once suggests a fire precaution. Again, the requirement may demand a minimum window-opening in a wall proportionate to the floor area of a room—in the interest of health, evidently.

Elsewhere, it may be that a maximum limit is imposed upon window area in terms of the total wall area. It may be assumed—and rightly—that here the question of stability is implicated. But it may not be so obvious that considerations of fire risk are also involved since (though it is not commonly appreciated) there is frequently a danger of fire spreading from the windows of a building on one side of a street to the building opposite. Still another fire-precaution lies behind the limitations of the area of openings in external walls. The National Fire Services require a certain extent of wall-area to afford a fireman, working from a ladder on

the face of a building, a sufficient screen from the flames within.

It is to the builder's ability to analyze the principles behind the by-laws, as much as to their literal interpretation, that he will owe the smooth-running of his business.

It will be found that the by-laws relate not only to minor alterations and additions to existing buildings, but to building work of all kinds. Generally the requirements are expressed simply in terms of empirical rules which can be easily followed by the ordinary builder.

Specialist Repairs

On the other hand, there are some materials and methods of construction that cannot be so legislated for, and the requirements have to be expressed in terms of loads and stresses. Such, for example, are buildings wherein the loads are transmitted to the foundations through a framework of steel or reinforced concrete, any alterations to which would call for the technical knowledge of the structural engineer to make the necessary calculations. In the remote chance of the repairer being called upon to execute alterations to such a building, unless he possesses the requisite technical knowledge himself, he would be well advised not to tamper with such a structure except under the direction of a specialist.

In other circumstances, where the building is of the more traditional construction, the capable builder will usually find it quite within his ability to follow the behests of the by-laws in such a way that the building will not be brought out of compliance by reason of any minor alterations or additions that he may have to make to it.

For many years, building was carried out on traditional lines employing the same materials used in the same manner as had been the practice from generation to generation. In such conditions it was possible to legislate in hard and fast terms appropriate to the circumstances. But the subsequent introduction of new materials and methods of construction, as well as advancement in science and research, have to be provided for in building-laws, not only in the interest of economy but in actual efficiency.

Too frequent revision of the building-laws is apt to cause confusion, and, moreover, the revision of by-laws takes time. Modern development in building has become so accelerated that, however frequently a revision is undertaken, a lag between building practice and building-law is inevitable.

In many cases an attempt has been made to provide the necessary elasticity to a requirement by diluting its terms with such expressions as "adequate", "sufficient", "or other means". Such devices may have the effect of leaving the matter to the discretion of the local surveyor or building inspector.

The Model By-laws of the Department of Health for Scotland, for regulating building in Burghs, introduce into some of the clauses such a proviso as specifically to invest the Dean of Guild Court with the right to exercise discretionary power in respect of the matter concerned.

The power of modification or waiver of the English by-laws is

not expressed in the by-laws themselves, though a notice appears at the head of the London County Council's by-laws drawing attention to "the Council's Power of Modification or Waiver under Section 9 of the Act". Section 9 of the London Building Acts (Amendment), Act, 1935, is in the following terms:—

"The Council may on receipt of an application in relation to any particular building or structure or part of a building or structure modify or waive upon and subject to such terms and conditions (if any) as they think fit any of the requirements of any by-laws made or having effect as if made in pursuance of this Act."

In the published by-laws applicable to other parts of England there will probably be no such bold invitation to observe the possibility of modification or waiver. Nevertheless such a provision is made in the Public Health Act, 1936—under the authority of which the by-laws are made. Section 63 of the Act grants the power of modification or waiver in the following terms:—

"Where a local authority consider that the operation of any building by-law in force in their district would be unreasonable in relation to any particular case, they may with the consent of the Minister relax the requirements of the by-law or dispense with compliance therewith.

"Provided that the authority shall give notice of any such proposed relaxation or dispensation in such manner and to such persons, if any, as the Minister may direct, and the Minister shall not give his consent before the expiration of one month from the giving of the notice and, before giving his consent, shall take into consideration any objection which may have been received by him."

Compared with the methods of either the Scottish by-laws or the London Building Acts, the mechanism for the administration of relaxation adopted by the Public Health Act may appear cumbersome and slow, but it must be remembered that the proviso regarding the giving of a month's notice to certain persons concerned is qualified by the words "if any", and would only be invoked in cases where the consent to a relaxation of the by-laws might adversely affect adjoining owners or other persons directly concerned.

In considering any such concession in regard to by-laws under any power of modification or waiver, the decision usually depends on the evident purpose or purposes behind the by-law in question, and whether the alternative proposed would satisfy the purpose as efficiently as the specific requirement of the by-law.

Temporary Work

Obviously, some degree of permanence must be regarded as an essential of all building, for it would be futile to insist on compliance with some requirement if such compliance were not continuous. Yet it is conceivable that a building or a part of a building might be wanted for a limited period; or, alternatively, that it might be desired to employ a material which though naturally short lived, might be practically permanent if suitably maintained —such as wood or steel exposed to the weather.

A concession to meet such circumstances is made in Section 53 of the Public Health Act, 1936. This section empowers a Local Authority, in approving the use of a short-lived material, to set a time limit to that approval so that the removal of the structure in question may be obtained if found

desirable at the end of that period, or at the end of such further period as the case warrants. In clause 79 of the Ministry of Health Model By-laws is to be found a list of the materials contemplated.

Part IV of the London Building Acts (Amendment) Act, 1939, accomplishes the same end in a somewhat different way. Under this enactment, the London County Council is empowered to consent to the erection or retention of a building or structure which is not in conformity with the ordinary requirements of the Council's Building By-laws, and the erection or *retention* of such a building or structure is forbidden except with the Council's consent. In this way, each case is judged on its merits without restriction to any list of specified materials.

The Local Authority

It will have been gathered from the foregoing that as far as the legal matters related to building are concerned, the Local Authority plays a very important part. Since the Local Authority as an elected body is mainly dependent on its technical staff for advice on its course of action in building matters, it will scarcely be necessary to indicate the wisdom of making contact with the responsible official concerned before embarking on any alterations or repairs to an existing building.

While the local surveyor or building inspector in the course of his duties must enforce the observance of the building-laws, yet it is only natural that he should wish to fulfil his task with as little trouble as possible; and the builder will probably discover beneath the cloak of officialdom, a dispenser of useful advice and help, based on knowledge of the building-laws.

At the outset the question will be decided regarding the legal aspect of the work proposed—whether it is in fact a repair within the legal meaning (in which case the work will be free from official control); or whether the so-called repairs amount to an alteration or addition to the existing structure and therefore are subject to the operation of the by-laws and other legal requirements.

In the latter event, a formal application or notice to the Local Authority will probably be necessary. The nature of the information required and the manner of its presentation will generally be found fully set out in the by-laws themselves. Some authorities require the information to be entered on a printed form which they furnish on application. Any special information or request that circumstances render necessary should be contained in a covering letter.

Attention to Detail

When the work is such that drawings are called for in making application, they will probably be required in duplicate. In making such drawings it should be remembered that what is required is lucidity, and not necessarily a demonstration of draughtmanship. An elaborately lettered heading will not compensate for the trouble caused by the omission of the North point, nor will any amount of elaborate shading be as helpful in the understanding of a plan or section as a simple scale drawn at the bottom of the sheet.

Again, when submitting an application, it is wise to deliver

it personally to the responsible officer. He will probably notice at once any matter constituting a breach of the by-laws, and it is a saving of time and trouble (to himself as well as to the builder) to ensure that the application is such that the Authority could approve, rather than it should be refused and thereby necessitate another application entailing the preparation of another report from himself to his Council.

Surveyor's Power

The building-surveyor cannot usurp the statutory powers of the Local Authority by signifying either approval or disapproval of an application, but it sometimes happens that, where time is an important factor and the builder is anxious to start the job at once and avoid the delay of awaiting the next meeting of the Council, the Surveyor may intimate unofficially that the applicant may carry on with the work *at his own risk.* This means that, in the event of the Local Authority subsequently withholding consent, the onus of any alteration to, or even the demolition of the work carried out, must be borne by the applicant. As a matter of fact, however, when such tacit approval is intimated, the attendant risk is negligible, as the officer responsible for advising the Council will have already made up his mind to recommend that the proposal be approved.

While the building by-laws constitute the main item in the builder's legal dealings, there are several other local laws which the builder undertaking minor jobbing work may encounter. Some of these are also dispensed by the Local Authority and may relate to widely differing subjects—the formation of crossings in the pavement; the fencing of steps and areas; means of escape from fire; the separation or uniting of buildings; the observance of building line; and the water, gas and electric services (where these are undertaken by the Local Authority.

Some Local Authorities include the requirements relative to such matters within the same covers with the other building by-laws. Where they are not so included, however, and without some warning, their existence may not become evident to the unwary builder until he inadvertently commits some breach of them; for such requirements may be made not only under the authority of some general Act, but, in some cases, under a local Act or a number of local Acts peculiar to the borough or county to which they refer.

Here again is an instance of the advantage of the friendly co-operation of the official of the Local Authority charged with the duties of examining building applications, as where such extra by-laws are administered by the Local Authority, they will be familiar to him, and he will probably indicate them.

Company Services

Where any of the services—water, gas or electricity—are not undertakings of the Local Authority, but the undertaking of a separate company or board formed for the purpose, the by-laws or regulations applicable to the service in question, will be administered by the responsible undertaking and, for all practical purposes, as far as the builder is con-

cerned, the undertaking may be regarded as the Local Authority in matters related to the service in question. If he be wise, he will take an early opportunity of making the acquaintance of the inspector or other responsible official of the undertaking and obtain a copy of the by-laws or regulations.

Where laws are more or less explicitly stated in black and white—such as have hitherto been considered—their due observance is mainly dependent upon the builder ascertaining their existence and where a copy may be obtained. There are laws, however, which are not so definitely expressed, but, broadly speaking, consist of certain accepted fundamental principles of justice.

Rights of Adjoining Owner

The laws relating to *easements* are somewhat of this nature. Their underlying objects, so far as they relate to the matters here under consideration, are to prevent a person from building or altering a building in such a manner as to detract from, or nullify some prerogative related to the property of the adjoining owner.

A right in relation to adjoining property may have been acquired in various ways. For instance, a person may wish to build a house *A* in such a position and so planned that for the sake of convenience one of its doors has to be approached from the public way across the adjoining site *B*. He may enter into an agreement with the adjoining owner to do so. In such a case there will probably be a document signed and sealed, which the building owner can produce in support of his right-of-way, in order to prevent the adjoining owner of *B* from building, or so altering his building, as to prevent the use of the way to the door. Such a case is simple, and the duty of the builder working on the premises *B* will be clear. Having noticed the way in, he will make enquiries regarding the rights to it.

But let us consider another set of circumstances. The builder is employed to carry out repairs to the building *B* involving an extension of such a nature as to interfere with an existing privilege: as, for instance, materially to impair the light or air admitted through a window of the adjoining building *A*. Assuming the window to have existed for some years and that the agreement, if there ever was one, cannot be found, what is the position?

In such a case the mere absence of a written document may not constitute an obstacle to the owner of the window sustaining his right to an *ancient light*, as it is legally termed. (The word "ancient" thus used bears little relationship with the meaning attributed by historians or antiquarians.) At one time, to establish his right to easement, the owner had to prove that the enjoyment of the privilege had existed "during time whereof the memory of man runneth not to the contrary". The precise length of such a period is problematic. Such laws depend very much upon the legal decisions given by the Courts, and the law thus moulded, appears here to tend as much to shortness of human memory as to the modernization of antiquity.

In the circumstances, the best course for the builder carrying out any alterations, when confronted with a problem in this uncertain

and complicated sphere of the law, is to obtain legal advice.

The fact that in the majority of cases, buildings are so designed as not to be likely to suffer detriment from the ordinary circumstances attendant upon a minor modification or extension of the next building, should not lull the builder carrying out such work into any false assumption of security. He should always keep an eye open for the possibility of an infringement of the rights of an adjoining owner. Easements and other rights often exist unnoticed, as it were. Such, for instance, is the fact of the part-ownership of a party wall, whereby (even were the by-laws to permit it) the adjoining owner's half must not be adversely affected by any repairs or alterations. Again there is the natural right of the adjoining owner to lateral support to his ground—that is to say, one must not excavate so close to the boundary, or remove a retaining wall or carry out any such work, as would result in disturbing the adjoining ground.

Other Easements

The necessity for observing such precautions may be obvious, but there are other matters which may not be so apparent, and yet constitute an easement—such as the discharge of a rainwater pipe or the run of a telephone wire.

It would be impossible to enumerate all the things which might constitute the subject of an easement—if for no other reason than for that once stated in a case tried by the House of Lords, that "the category of easements must expand with the circumstances of mankind".

There yet remains another way—in the opposite direction—whereby a builder may come into conflict with the rights of the adjoining owner. The instance has already been cited wherein a building *B* was so altered as to infringe a right of light in a building *A* adjoining. There is also a corresponding set of circumstances possible which might have the reverse effect. Let it be imagined that, instead of an existing ancient light in building *A* the owner of *B* were to form a window in such a position as to overlook the site of *A* and in such close proximity to the boundary that were the owner of *A* ever to build up to his boundary line he would interfere with the new window.

Possible Contingencies

It might be said by the builder introducing the window into the building *B* that, inasmuch as he had not interfered with any right vested in *A*, the owner of that property had no cause for complaint. But from the point of view of the latter, although he suffer no present inconvenience from the new window, yet in the course of time, a right of light might accrue to the owner of building *B* (in the same way as was previously suggested in the case of the window in *A*); and whether the owner of *A* would ever be likely to wish to build in front of it is not the whole of the question.

The general effect of an easement is to enhance the value of the building benefiting by it while correspondingly detracting from the value of that over which the right is acquired. In the circumstances, it would not be surprising if the owner of the building *A* took such steps as might be necessary to prevent such a contingency.

To generalize, it behoves a builder not only to avoid the infringement of the adjoining owner's rights, but also abstain from doing that which might ultimately create an easement in favour of his employer unless, of course, his employer, having been duly warned, is prepared to run the risk of possible action by his neighbour.

Builder and Employer

This outline of the law relating to the business of building repairs would not be complete without a word as to the builder's personal responsibility to his employer.

When a building owner pays for work to be done by a person professing and calling himself a builder, it is generally held that he has a right to expect "reasonable skill", and the builder may be held responsible for any loss or damage (whether to the existing work or to the repairs themselves) which may be incurred through incompetence or neglect in the carrying out of the work.

Although the building by-laws are concerned with the question of stability, they do not contemplate every eventuality and do not relieve the builder from the responsibility of exercising reasonable skill and taking due precautions in the execution of his work. Even when he is carrying out a scheme which has been evolved by the employer and where the manner of its execution is a matter of specific instructions, the "skill" of the builder is still due to the employer, and in the event of any part of the scheme being inexpedient or likely to result in some part of the completed building lacking stability, it is the duty of the builder to draw the employer's attention to the fact.

Such jobs as running a drain in close proximity to existing foundations demand that the levels should be noted and compared. In cutting an opening in a wall, regard should be had to the condition of the existing work in relation to the loading to be placed on the jambs of the opening. When an alteration incurs any change in the loading, the sufficiency of the structure to sustain the loading should be investigated, and in this regard it must be remembered that the stability of an existing structure can be adversely affected by a reduction in loading.

Safety First

Having drawn the employer's attention to any unsatisfactory aspects of the proposal (preferably in writing), and if then the employer should adhere to his own opinions, the builder must be guided in his actions by the circumstances and common sense. Where, however, the carrying out of the proposal would have such results as to be a source of personal danger to the occupants of the building, the overriding principle in this, as in all problems relating to building should be—*safety first.*

Under no circumstances should any scheme be engaged upon which would be likely to infringe on any of the laws mentioned herein, and the importance of playing for safety cannot be too heavily stressed. To safeguard his professional reputation the builder should, in all cases of doubt, consult the laws in question first and then act afterwards.

By adopting this simple rule the builder will avoid endless legal complications, and he will be establishing that sound reputation which will reap its own reward.

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Page numbers in italics refer to illustrations

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